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ORIGINAL COMMUNICATIONS.

Notice *of some* New Species *of* British Fresh-Water Diatomaceæ. By William Gregory, M.D., F.R.S.E., Professor of Chemistry.

Having examined with some minuteness the fossil Diatoms in the Mull earth and in the Glenshira sand, both of which deposits yielded a very large number of species, I felt desirous to compare with them the species at present living in our waters. Accordingly I obtained, from various friends, gatherings from a great many different localities, both in England and in Scotland. Those which I have been able to study with some care, up to the present time, are almost all from fresh water, and, postponing to a future opportunity an account of the marine gatherings, I propose now very briefly to notice the results obtained from a number of fresh-water gatherings, more especially with reference to such species as are either altogether new or new to Britain.

It is well known that in no department of Natural History are the species, whether recent or fossil, so universally distributed over the earth's surface. All the more common species are found, according to Ehrenberg, in his recent great work, 'Microgeologie,' not only in the Arctic and Antarctic regions, but under the Equator, between the tropics, and in the temperate zones. But few forms seem to be characteristic of any country or quarter of the globe. The remarkable genus *Terpsinœ,* and a few others, have not yet occurred in Europe, but are found at widely distant localities in other parts of the world. A very striking example of the wide-spread distribution of diatoms is that of a beautiful little *Pinnularia,* which I first noticed in the Mull earth, and which Mr. Smith, who shortly afterwards found it recent at Grasmere, named *Pinnularia latestriata,* a name which I adopted instead of *P. Hebridensis.* I have since met with it in at least three-fourths of all the gatherings I have examined from fresh water, although invariably scattered. I could find no figure of this species in

any work to which I had access, neither in Ehrenberg's Atlas of 1838, in Kützing, nor in Rabenhorst. Nor did any English observer know it. But I now find that Ehrenberg had described it as *P. borealis* ten or twelve years ago, although his figure, which, if published, appeared in the Berlin Transactions or the Berlin Monthly Reports, was entirely unknown to all our authorities in this country, none of whom, more than myself, have been able to consult Ehrenberg's very numerous papers on the Berlin Transactions, or Monthly Reports, except as quoted by Kützing or Rabenhorst, neither of whom noticed this species. I mention these facts, to explain how it was, that a species long ago described, and I believe figured, by Ehrenberg, was regarded by all our authorities as new when I found it in the Mull earth two years ago. And now I find, in Ehrenberg's Microgeologie, not only that the species is common, which, so far as concerns Britain, I had myself noticed, but that it is one of two specified by him as occurring in every latitude and in every quarter of the globe, more uniformly than any others.* The fact, that it so long escaped notice in this country is explained by its occurring always scattered, and

* The two forms named by Ehrenberg are *Pinnularia borealis* and *Eunotia* (*Nitzschia*, Sm.) *amphioxys*. Having lately examined about 60 small specimens of earth, found attached to plants in the University Herbarium here, and given to me by Professor Balfour, I find, in accordance with what is stated by Ehrenberg, that *every one* of these specimens of earth, which are chiefly from different parts of South America, contains diatomaceous exuviæ, and many of them in considerable quantity. I have detected, in examining only one slide of that part of each earth which is insoluble in acids, not only Diatomaceæ, to the extent of from 20 to 40 or even 50 species, in each case, most of which are identical with British forms, but also spiculæ of Sponges, and many Phitolitharia, exactly as Ehrenberg has done in the numerous similar earths analysed by him. It is most remarkable, that the two species above named occur in at least four-fifths of all the exotic earths I have yet examined; and one of them, *P. borealis*, in very nearly the whole of them. I may add, that I seldom explore a fresh-water gathering at home without finding one or both of these two species. Sufficient attention has not yet been paid to the fact of the invariable presence of Diatomaceæ, &c., in all earths in which plants are found. Ehrenberg, in his 'Microgeologie,' has established the fact as an universal one, and pointed out the important bearing it has on the *growth of the soil*. Indeed, it is difficult to imagine a more effectual agent in the transference of silica from the waters to the solid earth, than the growth of Diatomaceæ, the shells of which are as indestructible as their multiplication is rapid. Ehrenberg is of opinion that they live in the soil, as well as in water, and the constant presence of moisture in the soil renders this conceivable. Although the proportion of silicious matter, dissolved in ordinary water, is but small, it is evidently sufficient to supply the shells of millions of Diatoms in a very short time; and it is therefore probable, that as fast as it is extracted from the water by them, it is dissolved from the rocks or earths in contact with the water; so that the supply never fails.

never, as many other forms do, in crowds together. But this consideration shows the necessity of minute search, without which many of the scattered forms would escape observation. Many similar examples might be adduced.

It would be intolerably tedious to give a list of all the species observed in these gatherings, of which I have examined, more or less minutely, upwards of 200. I may state that, with few exceptions, I have met with all the known British fresh water species, and that I have found various new localities for many rare and curious forms.

Few, if any, of the new species which have occurred, are confined to one locality; most of them have been found in several and these widely distant stations.

These new species may be conveniently arranged in three sections: 1. Those already described by foreign naturalists, but now first detected as British forms. 2. Those which, although I have myself recognised them as entirely new forms, have been also, either about the same time or subsequently, observed by others. Although these are still unpublished MS. species, and in many cases, my own observations were by much the earliest, yet as I find that these forms have been named by Mr. Smith, I adopt his names, to avoid the confusion arising from synonyms. 3. Species which, so far as I can discover, have nowhere as yet been described or figured.

I. Species, now first found as British, but known to foreign authors.

1. *Eunotia tridentula*, Ehr., fig. 1, Pl. I.*—Banffshire, R. Findhorn.
2. *Navicula follis*, Ehr.—Lochleven, (qu. ? Trochus ?)
3. *N. dubia*, Kütz.—Elgin, Lochleven.
4. *N. bacillum*, Ehr.—Lochleven.
5. *Pinnularia nodosa*, Kütz. (Legumen, Ehr.)—Elgin, Elchies, &c.
6. *P. megaloptera*, Ehr.—Benrinnes, Elgin.
7. *P. dactylus*, Ehr.—Benrinnes, Elgin.
8. *P. pygmaea*, Ehr. (*Nana*, W. G.)—Near Edinburgh.
9. *Stauroneis Legumen*, Kütz.—Elgin, R. Findhorn, Duddingston Loch.
10. *S. ventricosa*, Kütz.—Elchies, Elgin.
11. *Cocconema cornutum*, Ehr. ?—Lochleven.
12. *Gomphenema subtile*, Ehr., Elgin.—Glenshire sand.
13. *Meloma distans*, Ehr. (Gallionella).—Elgin, Elchies, Lochleven.

I do not give these as in all cases absolutely distinct species,

* The species are numbered to correspond with the figures in Plate I.

but only as the forms figured under the names here given by Ehrenberg and Kützing. It is indeed probable that *Pinnularia megaloptera* is only a long form of *P. costata* (*lata*, Sm.); and that *N. dubia* may be a variety, as some believe, of *N. firma*, although I am rather inclined to think that *N. amphigomphus*, Ehr. and *N. dilatata*, Ehr., both of which occur in Lochleven with *N. dubia*, may be forms of one species with the latter, but distinct from *N. firma*. For this reason, I have only mentioned *N. dubia* in my list. The remarkable form which I have referred to *N. Bacillum*, Ehr. is perhaps, as I find from Ehrenberg's 'Microgeologie,' rather his *N. Americana*, although, to judge from his figures, these two form but one species. It is also probable that *Pinnularia Dactylus* is only a variety of *P. major*.

II. MS. species; named by Prof. Smith, but unpublished.

13. *Navicula apiculata*, Sm.—Mull earth, Elgin, Dhu Loch, in Glenshire.

14. *N. rostrata*, Sm.—Near Haddington, Lochleven; near Oban, Linlithgowshire, Dhu Loch in Glenshira, Elgin; also recently near Hamilton, and at Borthwick Castle.

15. *N. scutelloides*, Sm.—Norfolk, Lochleven.

16. *Mastogloia Grevillei* (for the locality only), Lochleven.*

At one time I regarded *Navicula scutelloides* as one of the innumerable varieties of *Navicula varians*, a form to which I have lately directed attention, as showing the extent to which shape and outline may vary on the diatoms, without materially affecting other characters. But my friend Dr. Greville has suggested that the form in question is rather a *Cocconeis*, and his opinion possesses much weight.

III. Species now first described and figured.

17. *Cymbella?*† *sinuata*, W. G.—Dhu Loch in Glenshira,

* I give a figure of *Mastogloia Grevillei*, first observed by Dr. Greville in a gathering from the Pentland Hills. I subsequently found it in my Lochleven gathering, but not having then seen Dr. Greville's species, I did not at first recognise it. It is scarce on the gathering from Lochleven, but will probably be found in abundance in some part of the lake, or in some of the streams which supply it.

† I am by no means sure that this form is correctly referred to the genus *Cymbella*. I at one time supposed it might be a *Eunotia*, or a *Pinnularia*, or possibly a *Gomphonema*. But the general opinion among those to whom I have shown it is that it comes nearest to *Cymbella*. It is marked, however, as doubtful. Some have conjectured it to be an abnormal state of some form, not specified. But it occurs in so many localities, always with the same characters, that I cannot but regard it as a normal and distinct species. Dr. Greville has recently met with it in various gatherings from the vicinity of the Bridge of Allan, and I have again found it in several from the neighbourhood of Hamilton.

and Loch Etive, Argyllshire; R. Calder and R. Avon, Lanarkshire; Lochleven. Fossil in the Mull earth and Glenshira sand.

I have thus named the curious little form represented in fig. 17. It is narrow, slightly arcuate, with rather square, slightly expanding apices. On the generally concave side are three rounded but gentle prominences; the central one considerable, the lateral ones, which are near the ends, very slight. Striæ conspicuous, sub-distant, about 20 in ·001, not reaching, or hardly reaching, the median line, which seems to be, as in the known *Cymbellæ*, a little nearer the ventral surface. There is in most cases a blank space round the central nodule. Length from ·0008 to ·0012 inch.

The characters of this species are very constant. It varies somewhat in size, and a little also in the form of the apices, which are in some less square than in others.

I first noticed it in the Mull earth, then in a slide mounted by Professor Smith for *Gomphonema gemmatum*, the locality of which was not given; then in the Glenshira sand, and subsequently in the other localities named. It has always been, hitherto, scattered, and does not seem to have been yet found in the spots where it grew. But it appears to be widely diffused.

18. *Cymbella turgida*, W. G. Elgin.—This pretty species has only occurred to me, as yet, in one British gathering, from a moss near Elgin, but I have seen it in two specimens of soil from South America. It is short and broad, the dorsal line almost perfectly circular, while the ventral one is nearly straight. The apices are acute, and somewhat produced. The two halves are very unequal, the dorsal being very broad, the ventral remarkably narrow. Striæ very conspicuous, strong and sharp, about 24 in ·001. Length ·002 to ·0025 of an inch. Of the British *Cymbellæ*, *C. maculata* comes nearest to it, but differs in form, in the shape of the apices, in striatum and in general aspect. In the Elgin gathering the only one in which as yet it occurs, the species is very uniform and well marked on its characters.

19. *Cymbella obtusa*, W. G.—This species occurs in many gatherings; as Lochleven, those from Banffshire, from Lanarkshire, Argyllshire, &c. Dr. Greville finds it in one from Braid Hills. It is rather small, with very obtuse apices, and the striæ are inconspicuous, much finer than in any of the known species. I think I have seen it named *C. Scotica*, but Professor Smith's figure of that species, which accurately represents a very common form, is very narrow and has extremely acute apices. Length ·001 to ·0015. Striæ about

36 in ·001. I name this and the preceding species with some hesitation, not that they are not well-marked forms, as may be seen from the figures, but because the genus *Cymbella*, as well as the allied one *Cocconema*, is not in a satisfactory state, and requires a thorough investigation, in which the forms I here describe must be considered. The same remark applies to the next species.

20. *Cymbella Pisciculus*, W. G.—This form occurs in a very interesting gathering from Norfolk, and Dr. Greville has recently found it near Bridge of Allan. I have also lately seen it in various gatherings, including that from Lochleven. It is rather large, broad, and has somewhat square apices. Length about ·0016. Striæ about 30 in ·100.

21. *Cymbella Arcus*, W. G.—This pretty form I have very recently found in two gatherings from the neighbourhood of Hamilton. The ventral surface is straight, the dorsal highly arcuate, and slightly undulating, broad in the middle, very narrow towards the extremities, like a strung bow. The apices are rather square, expanding a little, after a slight construction. The striæ are best seen about the middle, where the frustule is broadest. Length about ·0014. Striæ about 30 in ·001.

22. *Navicula cocconeiformis*, W. G.—Occurs in Elgin, Elchies, and some other Banffshire localities, and Lochleven, and recently in various gatherings from different parts of Scotland. In form it is short, broad, nearly oval, but with a slight angularity in the middle, and flattened apices. Some specimens are almost rhombic. In shape it comes very near to *Cocconeis flexella* (Thwitesii), and it has much the aspect of that form, except that the median line is quite straight. Striæ not resolvable. Length from ·0006 to ·0012. I understand that this form has been named *N. nugax* by Professor Smith, but I consider my own name, given much earlier, as more characteristic. Besides this, Dr. Greville has lately figured it under the name here adopted.

23. *Navicula lacustris*, W. G.—This fine species has only as yet occurred in the gathering from Lochleven, in which, though not abundant, it is yet far from scarce. It presents two well-marked varieties, α and β, which pass into each other by intermediate forms: α, which is rather more abundant than the other, is elliptico-lanceolate, with acute apices. Nodule bright in the centre, but without definite outline. Median line double. Striæ fine, but distinct, slightly inclined; about 28 or 30 in. ·001; length from ·0016 to ·0025 inch: β agrees in every point with α, except in outline. It is broad, has straight sides, sometimes even a little incurvated, and sud-

denly contracted to narrow produced extremities. These two varieties are seen in figs. 23 and 23 β, and there exists an intermediate form. The only species with which this could in any way be confounded is *N. firma*, var. β. But the latter is longer and larger, always of a brown colour, and in *N. firma* not only are the striæ much finer and less conspicuous, but they are almost exactly parallel. It is not easy in a drawing to give certain peculiarities of aspect, but any one who compares the two species, *N. firma* β and *N. lacustris*, will perceive that the latter has an aspect entirely different from the former. Moreover the side lines, always seen in *N. firma*, never occur in *N. lacustris*.

24. *Navicula bacillaris*, W. G.—This pretty little species was first observed in several gatherings from Duddingston Loch, and has since occurred in many others, as Lochleven, Elchies, Elgin, and in large quantity in two from the neighbourhood of Dundee. It is linear, narrow, with rounded and slightly pointed apices. It has a very smooth aspect, and the striæ are so fine that it is difficult to resolve them. Length from ·0012 to ·002 inch.

25. *Navicula lepida* α, W. G.—This form occurs in the Lochleven gathering, where it is not rare, and I have recently seen it in others, as in those from Hunter's Bog, and in one of Dr. Balfour's from Borthwick Castle.* It is small, of a narrow oval, and has at first sight a smooth polished aspect; but on closer inspection the striæ are seen to be by no means very fine, but rather difficult to catch from their transparency. They are distinctly but slightly radiate. The central nodule is indefinite, and assumes frequently the aspect of a hazy cross-band, approaching to that of a false stauros. It is a very neat and well-marked little form, and its characters are very constant, varying considerably only in length; the average being about ·0015 inches.

25β. *Navicula pileda?* β, W. G.—This is another small form, which in some points is so near the last, that I regard it for the present as a variety of *N. lepida*. It is small, of a very short oval shape, and the striæ are both more distinct and more radiate than in *N. lepida*, but yet it exhibits at first sight the same apparent absence of striation. The difference is in the structure of the nodule, which in the present case is always very definite, transparent and glassy; the same peculiar aspect is seen in the terminal nodules; this form hardly ever varies even in length. I have only once seen a specimen a good deal longer and narrower in proportion, and consequently

* Dr. Greville has also found it in a recent gathering from Duddingston Loch (April, 1855).

in form close to *N. lepida*, but the nodule retained its characteristic aspect

26. *Navicula incurva*, W. G.—This elegant species I have observed in two or three gatherings from the River Findhorn, and very sparingly in that from Lochleven. It is rather narrow, with somewhat angular shoulders, contracted suddenly towards the apices, which are produced and square, and more gently towards the centre. Length about ·0017 inch. The striæ have not yet been resolved. It seems to belong to a group, all of which have irresolvable striæ, such as *N. producta* and *N. affinis;* but its very characteristic and constant form render it quite distinct.

27. *Navicula longiceps*, W. G.—This little form occurs in the Morayshire and Banffshire gatherings along with the equally minute species *Pinnularia linearis*, *P. subcapitata*, *P. gracillima*, and *N. bacillaris.* It is small, linear, narrow, but not very long, contracted near the extremities, and subsequently continuing of uniform width to the broadly rounded apices. Nodule indefinite, striæ not yet resolved. Length about ·0012 inch. It is more frequent in the Elchies gathering than in any of the others, and is very permanent in its characters. I have named it, from the peculiarly long shape of the contracted ends.

28. *Pinnularia biceps*, W. G.—This well-marked form occurs in the gatherings from Elgin, Elchies, and Lochleven, as well as in some others, and is by no means rare. It is rather large, linear, contracted towards the ends, and expanding into large round heads. The striæ which have, as in *P. divergens*, three centres of radiation, do not reach the median line, and towards the central nodule leave a large round blank space, on the sides of which of course the striæ are much shortened. There are two varieties: β, which is less constricted and subcapitate; and γ, which has three undulations on each side, and is capitate like the type. Length from ·002 to ·003 inch. Striæ about 24 in ·001 inch. This species approaches to *P. divergens*, which, however, is not capitate, and besides has the central blank space in the form of a broad false stauros, reaching to the margin, so that there are no striæ on either side of the central nodule.

29. *Pinnularia linearis*, W. G.—This little form occurs in the gatherings from Elgin, Elchies, and several other Banffshire localities, also in Lochleven and elsewhere. It is small, linear, narrow, very slightly narrower at the apices, and occasionally a little contracted just before them. The striæ are fine, very nearly parallel, reaching the median line. Nodule small, somewhat elongated; it has a distinct border, formed

apparently by a line parallel to the outer margin, and this border is very broad for so small a form. Length from ·001 to ·0012. Striæ about 40 in ·001 inch.

30. *Pinnularia subcapitata*, W. G.—This is another small and linear species, which is found in the same gatherings as the last, and also *P. vaciva*. It is linear, narrow, constricted, subcapitate, the ends rounded. The striæ are subdistant, conspicuous, short. Length about ·0013″.

31. *Pinnularia gracillima*, W. G.—This species occurs in the Elgin and Elchies gatherings, in others from Banffshire, and in various other localities. It is, I believe, the same as that which Mr. Smith has named *P. vaciva;* but I had named it long before, and as Dr. Greville has adopted my name in a recent paper in the Annals, I retain it. It is very narrow and long in proportion, varying a good deal in length, as from ·0014 to ·0025. It has a constriction towards the apices, which again expand into longish rounded heads. Striæ fine but distinct; I have not counted them. Dr. Greville has found this species in the district of the Tummel and elsewhere.

32. *Pinnularia digito-radiata*, W. G.—This species occurs in several gatherings from Duddingston Loch, also in Lochleven and elsewhere, and is not very rare. It is rather small, in form linear elliptic or elliptic-lanceolate, and somewhat narrow. It has a delicate aspect, and the striæ are distinct, though rather fine, except at the centre, and much inclined. The central nodule expands a good deal laterally, and from it on each side diverge five or six very strong striæ or costæ in a digitate fashion, as may be seen perhaps a little too strongly marked in fig. 32. This character comes out well under a high power. Length from ·0014 to ·002 inch. Striæ about ·25 in ·001″. This species has some resemblance to the more finely striated varieties of what I have named *N. varians*. But as *N. varians* occurs along with the new form they are easily compared, and it is seen that the striation of *N. varians* is much coarser and far more conspicuous, so that the aspect of the two forms is quite different.

33. *Pinnularia Elginensis*, W. G.—This species is another of the numerous capitate forms which occur in fresh water. It is rather small, not very narrow, with straight sides, contracted towards the extremities, and again expanding into somewhat square truncate heads. The nodule is rather indefinite, the striæ not conspicuous but easily resolvable, fine and very slightly radiate or inclined. It may possibly be a *Navicula*, but it is often very difficult to know to which of these two allied genera, *Navicula* or *Pinnularia*, we ought to refer a

species. It seems to be distinguished by the character of its striation from all similar forms yet described. *N. varians* sometimes takes nearly the same outline, but is at once known by its conspicuous and highly radiate striæ. Length about ·0013 inch. Striæ about 30 in ·001″.

34. *Pinnularia globiceps.*—This elegant little form occurs not unfrequently in a very beautiful gathering from Norfolk, the same in which I first noticed *Cymbella pisciculus.* I have met with it also, or at least a form much resembling it, in the recent mud from the Dhu Loch in Glenshire. It is well marked by its globular extremities and prettily curved outline, swelling a little at the middle part. The terminal nodules are very prominent, casting a shadow, the central are indefinite. The striæ are fine but sharp and distinct, not reaching the median line. They have three centres of divergence, and are entirely absent from a broad crucial space, like a large false stauros, the upper and lower parts of which pass into the long blank caused by the striæ not reaching the median line. In fact the arrangement of the striæ and blank space is like what we see in *P. divergens,* Sm. Towards the apices the blank space expands again. Length ·0014 inch. Striæ from 36 to 40 in ·001″. It is possible that this form may be allied to *P. Stauroneiformis,* or to *P. divergens,* as it is also possible that the two last named may belong to one species. The name must therefore be considered as provisional for the present. In any case it must be distinguished as a striking and well-marked form, even if only a variety.

N.B.—Since writing the above I have observed, in some gatherings from the neighbourhood of Duddingston Loch and Arthur's Seat, as well as in some from the Bridge of Allan, the latter made by Dr. Greville, and in one from Borthwick, made by Dr. Balfour, a form apparently allied to *P. globiceps,* which for the present I shall call *P. globiceps β.* It has a much less elegant curve, but in most points agrees with the form here described.

35. *Stauroneis obliqua,* W. G.—This very curious and well-marked species has only occurred, as yet, in the gathering from Lochleven, in which it is, though far from frequent, always to be found, from 3 or 4 to 10 or 12 in a slide. In form it is elliptico-lanceolate, usually rather short and broad, sometimes longer. The stauros is broad and distinct, but less so towards the margin, which, however, it reaches. The striæ are fine and slightly curved from the middle towards the extremities; but the most striking character is the peculiar position of the median line, which does not, as usual, unite the apices centrically, but has one of its ends on one side of

the apex, the other on the opposite side of the opposite apex, thus dividing the valve into two halves, which, although equal, are so placed that the narrowest part of one corresponds to the broadest of the other, as is well shown in the figures. In some cases, as may be seen in the larger figure, the median line is slightly sigmoid, but this is rare. The obliquity just described, which I do not remember to have seen in any other species, is invariably present; at least I have found it in at least 150 specimens which I have examined. The length is from ·001 to ·0022 inch. Striæ, by the measurement of Professor Kelland, 45 in ·001 inch. I may add that Professor Kelland thinks the median line is twisted, as it were on its own axis, to a certain extent.

36. *Stauroneis (?) ovalis*, W. G.—This very pretty little form first occurred to me in some gatherings made on the River Findhorn by my friend Mr. Crawford, of Overton. In one of these it is quite the predominating form, and in all of them *N. incurva*, already described, also occurs. I have recently found it, much more sparingly, in Lochleven, in which I also detected *N. incurva.* The form is a pure oval, ·001 inch long, and it is crossed by what at first I took for a stauros, which is broad and reaches the margin. But I cannot, with a high power, satisfy myself that this is really a stauros, as it seems to vanish, or is so transparent that it cannot well be traced. The valve appears to be convex, as when the stauros is brought into focus, the other parts are but dimly visible. The striæ have not yet been resolved. As the genus of this form is not yet determined, I retain the name *Stauroneis* with a mark of interrogation. It is more probable that it may prove to be a *Cocconeis.* At all events, it appears to be a distinct and well-marked species. Length about ·001 inch. I have recently observed it in two gatherings from Lanarkshire.

37. *Stauroneis dubia*, W. G.—This is a still smaller form, and, as the name indicates, its true position is not quite settled. It occurs in some of the gatherings from Duddingston Loch, and in others from the Hunter's Bog, and is far from scarce. It is small, narrow, of an elliptico-lanceolate form, the apices slightly truncated. There is a stauros, whether true or false is not yet ascertained, but probably true. When examined under a high power, the valve exhibits two parallel marginal lines within the margin on each side, the stauros not reaching farther than the inner one of these lines. The striæ have not yet been resolved. Length from ·0008 to ·0012 inch.

38. *Surirella tenera?* W. G.—This pretty form occurs in

the Elchies gathering, where it is frequent, along with *S. biseriata* and *S. nobilis*, so that it can be at once distinguished from them. It has exactly the form of *S. nobilis*, but is smaller and rather narrower in proportion. It differs from *S. biseriata* in having one end round, the other acute. From both of these species it differs still more in the fact of having its canaliculi very much narrower and more numerous. Its length is from ·003 to ·005 inch. Canaliculi fine, about 10 in ·001 inch. It is possible that it may be the perfectly developed *S. linearis*, but I have not as yet been able to ascertain this.

39. *Gomphonema insigne*, W. G., *rude*, Sm.—This species was first observed in some gatherings from Duddingston Loch, but I found it subsequently to be pretty widely distributed. It is distinguished by its size and the coarseness of its striation. The S.V. is doubly conical, the angle at the broadest part being strongly marked. The F. V. is cuneate. Length from ·002 to ·0024 inch. Striæ 18 to 20 in ·001″. I believe that Mr. Smith has named this form, which I sent him when I first observed it, *G. rude*, but I am not quite certain of this. If so, there can be no objection to his name.

40. *Gomphonema ventricosum*, W. G.—This well-marked species occurs in a gathering from the banks of the Spey, near Elchies, different from that which I have spoken of as the Elchies gathering. The middle part is much expanded, and both extremities are obtuse and rounded, the longer limb being a little expanded at the apex. It is short and broad in proportion, and very uniform in its characters. Length about ·0014 inch. Striæ about 30 or 32 in ·001″. Dr. Greville has recently (April, 1855) found this species tolerably frequent in several gatherings made by him near the Bridge of Allan.

41. *Gomphonema æquale*, W. G.—This species occurs in the Elchies gathering, which is from a spring in the grounds of the house. I have seen it also in that from Elgin, and in some of the other Banffshire gatherings, as well as in some from Lanarkshire. It is shorter than the last, and is distinguished from it, as well as from other *Gomphonemata*, by the position of the nodule, which is central, whereas in other species it lies always nearer one end. In form it is linear elliptical, but towards the extremities it is suddenly contracted, and again expands, so as to be almost capitate. In this it agrees nearly with some forms of *G. tenellum*, from which, however, it differs, both in having much wider and coarser striæ, and in the central position of the nodule. Length ·001 inch. Striæ rather distant, not reaching the median line, conspicuous, about 22 or 24 in ·001″.

42 *Gomphonema Sarcophagus*, W. G.—This species occurs abundantly in the Lochleven gatherings, but it occurs also in several gatherings made near Edinburgh, and in others from Fife, Stirlingshíre, Lanarkshire, and elsewhere. Indeed it would seem not to be uncommon. In form it is linear, rather narrow, the sides gently curved, so as to form a sort of shoulder at the widest part, after which it contracts a little, and again expands to a somewhat truncate extremity. The opposite end is narrower, and, with the exception of a trifling expansion at the apex, becomes continuously narrower. These things give to it very nearly the shape of a coffin. The F. V. is, as usual in this genus, cuneate. Length about ·0014 inch. Striæ 20 to 22 in ·001″.

I have now only to add a few words on the distribution of the *Diatomaceæ* in our fresh waters. I have not only found, as Ehrenberg has done, that a large number of species occur in every locality, but even in the case of the forms just described, which, from their having been overlooked, might be supposed to be very rare, most of them have been observed in more than one, frequently in several different and distant stations.

It must not be supposed that the gatherings which I have examined are exhausted. The fact is, that only a small number of them, no doubt the most interesting and the most promising, have been at all minutely explored, and I would particularly direct attention to the fact, that with the exception of only two or three species, all the forms now figured are actually to be found in four gatherings, those, namely, of which I have spoken as Elchies, Elgin, Lochleven, and Duddingston Loch. Several of these forms were first observed in other gatherings, though not many, but in time they have all been found in these four. Nay, the Lochleven gathering alone has been found to yield nearly the whole of them. If, therefore, I had been confined to these four gatherings alone, I should have detected, by careful exploration, all the forms now figured as new. This shows what I formerly alluded to, the importance of minute examination, without which many interesting forms are daily overlooked. It is no argument against this to say that species cannot well be ascertained from a few scattered specimens, for what is rare and scattered to-day, may be found in abundance to-morrow. Thus the doubtful *Stauroneis* which I have figured occurs very sparingly in the Lochleven gathering. Had it never occurred but there, its character could have been easily ascertained. But in the Findhorn gatherings it occurs abundantly. *Stauroneis obliqua* occurs, at present, only in Lochleven, and that sparingly ; but

its characters are so well marked that we need not wait till it shall be found in abundance, as it probably will some day. It would, however, certainly have been overlooked in Lochleven, but for the minute search to which the gathering was subjected. The same remarks apply to *Navicula lacustris* and to *Navicula lepida*.

Whenever, therefore, a gathering is met with which appears to contain a great variety of forms, like the four above mentioned, it should be systematically and minutely searched, and any striking forms, no matter how scarce, noted and figured. If true species, they will most probably be found in greater abundance elsewhere.

It is much to be regretted that no work yet published contains figures of all the known species or forms named as species by their observers. Even in Ehrenberg's last great work, in which many hundred species are figured, I observe the names of about 350 species, most of which are described as remarkable or characteristic of certain localities, not one of which is figured, although most of the common species are many times represented.

Supposing, then, that all those forms which I have just described as new to science should prove to be good and distinct species, of which I cannot, of course, be sure, it is out of my power to ascertain whether they may not agree with some of the species named, but not figured, in his last work, by Ehrenberg. I ought to mention, however, that several of the species of my first section, new to Britain only, were considered by myself and others as new to science, till I found them figured in Ehrenberg's 'Microgeologie,' when of course I adopted his names for them.

An Account of the Structure *and* Relations *of* Sagitta bipunctata. By G. Busk, F.R.S.

The minute creature to which the above name has been given, though abundant, perhaps, in all seas, and noticed so long ago as in the year 1781, has received but little attention from zoologists in general. Its curious and interesting structure, however, and doubtful position in the animal kingdom, render it a subject well worthy of further research; and its minute size, and the extreme delicacy and transparence of its tissues, make it peculiarly an object of microscopical investigation. Though perhaps unknown, even by sight, to many of our readers, the *Sagitta bipunctata* will probably be met with on every part of the coast; and it may be procured,

without difficulty, at any rate in fine and calm weather, by means of a small muslin towing net over the side of a boat.

The animal, which has the form of a pointed needle, is from one to two inches in length or less, and transparent as the clearest glass. In warm, calm weather it swims on the surface of the sea, and occasionally in the most surprising numbers. In these latitudes it appears to be in a state of the most complete maturity in August and September.

The present account pretends to little originality, except in the figures, some of which were made by myself in 1852, from specimens taken in Sandown Bay in the Isle of Wight; and for others, I am indebted to Mr. Huxley, whose observations upon this creature were made in the course of the voyage of the 'Rattlesnake' in the seas of Australia. That accurate observer, who has also studied the British form, is of opinion that the *Sagitta* he examined in the southern hemisphere and elsewhere, is identical with that found on our coasts; and I have, therefore, no hesitation in availing myself of his figures, illustrating the nervous system.

The earliest notice of the animal which forms the subject of this paper was given by Martin Slabber* in 1781, by whom also the very appropriate name of *Sagitta* was applied to it. This notice, however, seems to have been forgotten until M.M. Quoy and Gaimard, when commencing their second voyage round the world, re-discovered the animal, as it may be said, in the Straits of Gibraltar. The species observed by them was named *Sagitta bipunctata*, and is probably identical with that now under consideration. This form and other species of the same genus have been since noticed and more or less accurately described and figured by several authors, amongst whom may be noticed Scoresby,† D'Orbigny,‡ Forbes,§ Darwin,|| Krohn,¶ Wilms,** Huxley†† and Busch.‡‡

* 'Physikalische Belustigungen, oder mikroskopische Wahrnehmungen von 43 in-und ausländischen Wasser-und Landthierchen.' Nurnberg, 1781.

† 'Account of the Arctic Regions,' vol. ii., Plate XVI.

‡ 'Voyage dans l'Amerique meridionale; Mollusques, p. 140, Plate X., figs. 1—7.

§ 'Annals Nat. Hist.,' 1843.

|| 'Annals Nat. Hist.,' 1st Ser., vol. xiii., p. 1.

¶ 'Anatomisch-physiologische Beobachtungen üb. die *Sagitta bipunctata*,' 1844. 'Nachträgliche Bemerkungen üb. den Bau der Gattung *Sagitta*, nebst der Beschreibung einiger neuen Arten.' (Wiegmann's 'Archiv.,' 1853, p. 266, Plate XII.) And Müller's 'Archiv.,' 1853, p. 140.

** 'Observationes de *Sagitta*, mare Germanicum circa insulam Helgoland incolente,' 1846.

†† Report of British Association, 1851. (Trans. of Sections, p. 77.)

‡‡ Beobachtungen üb. d. Anatom. u. Entwicklung einiger wirbellos. Seethiere, 1851, p. 93.

The present account of the animal, however, has been compiled chiefly from the observations of Krohn and Wilms, whose papers on the subject appear to include nearly all of importance that has as yet been made out respecting the anatomy and physiology of *Sagitta.*

The body of the *Sagitta bipunctata* is as transparent and clear as glass, cylindrical or slightly flattened, pretty regularly fusiform, though rather more attenuated posteriorly than in front (Pl. II. fig. 1), when it again expands at the extremity. It is divided into three distinct portions, the "head,' "trunk," and "caudal portion," which are separated from each other by transverse septa. Each of these portions will be separately described. Posteriorly the body is furnished, on the sides and extremity, with five delicate membranous expansions, which have received the name of "fins," though bearing no real analogy with the fins of a fish. These "fins" are all in the same plane, and spring from a line equidistant between the dorsal and ventral surfaces. The anterior pair of lateral fins, which are far smaller than the posterior, are situated nearly in the middle of the body, being equal in length to about 1-5th of the extreme length of the animal. The posterior pair of lateral fins, which are both longer and wider, extend from the posterior border of the former to within a short distance of the caudal extremity, where they terminate rather abruptly. Anteriorly the two pairs of fins are often apparently continuous with each other by a very narrow band of similar texture; so that, in fact, in many cases the lateral fins might be described as constituting only one pair, of varying width in different parts. The caudal fin is, however, quite distinct. It is broad and somewhat rounded, expanding like a fan from the posterior extremity of the body, and passing a short distance up on each side. These "fins" are composed of an excessively delicate and apparently structureless membrane, which is strengthened by very slender radiating fibres, placed very closely together, and appearing to be somewhat thicker at the base than more outwardly. Although very slight injury tears the fin in the direction of these apparent fibres—and its edge, thence, often appears to be fimbriated—the fibres themselves cannot be readily isolated, and there is every reason to believe that the edge of the fin in the perfect state is entire.

The *integument*, except on the head, is comparatively speaking thick and dense. It is covered with a very delicate epidermis, composed of rounded or polygonal cells. The existence of this epidermis was denied by Krohn in his first

memoir, but is admitted by him in his subsequent observations. When the animal is placed in spirits of wine, the surface presents numerous distinct, whitish, well-defined spots, which closer examination shows to be rounded eminences belonging to the cellular epidermis, and from which project minute bundles of excessively delicate, rigid filaments or *setæ*. These spicules, as they may be termed, were first pointed out by Wilms,* and the species on that account was termed by J. Müller, *S. setosa;* but from Wilms' description it appears to differ in no important particular from *S. bipunctata.* Wilms describes them as constituting a single series on each side, whilst Busch,† in speaking of a form termed by him *S. cephaloptera*, notices that they are disposed, in that species, in a double series on each side. Krohn also remarks that he has seen these spicular bundles, not only in *S. bipunctata*, but in several other species also; their existence, therefore, would seem to be general throughout the genus, and careful observation may, perhaps, educe from their disposition specific characters of some importance. In *S. bipunctata*, the spicules project on all parts of the body, but they appear to be more numerous on the anterior portion than elsewhere. So far as I have observed, they seem to be scattered irregularly over the surface, although Krohn states that they are apparently arranged in symmetrical longitudinal tracts on the two sides. He says also, that they occur on the caudal fin where they are disposed in a curved line across its width. In some species he remarks that they exist also on the posterior lateral fins.

As has been said before, all these bundles of spicules are placed upon rounded eminences, and in most cases they appear to radiate on all sides from the centre of the eminence; but closer examination will sometimes show that they are disposed in a simple line, and in close contiguity. This is the case, at any rate, according to Krohn, in *S. bipunctata.*

Notwithstanding their rigidity, the filaments, of which these spicular bundles are constituted, have nothing in common either with spines (aculei) with which Wilms compares them, nor with *setæ*, as they are termed by Busch. According to Krohn they are epidermic processes. And this notion he remarks is supported by the circumstance that the spicules, like the epidermis itself, are detached with extreme readiness, and consequently are only to be observed in perfectly fresh specimens in a good state of preservation.

Some analogy may, perhaps, be conceived to exist between the filaments of which these epidermic spicules are consti-

* L. c., p. 11, fig. 1, 16. † L. c., p. 93.

tuted and those by which the "fins" are strengthened. With reference to the latter, Krohn remarks that after repeated observation he is convinced that these fibres are closely allied to the *setæ* of Annelids. Like these they are flexible to a certain extent, and are readily broken into pieces. In form they exactly resemble the simple or capillary *setæ*. He remarks also, though this hardly accords with my own observation, that they are merely loosely imbedded in the homogeneous substance of the fin; since they may often, in otherwise uninjured "fins," be seen bare for a considerable extent. At any rate their connection with the substance of the fins is by no means so close as he was formerly inclined to believe.*

Immediately beneath the integument is placed a layer of longitudinal muscles extending uninterruptedly from the head to the caudal portion of the body. These muscles are disposed in two broad bands, one situated on the dorsal and the other on the abdominal aspect, and separated on each side by a clear space, which is brought more distinctly into view, as Krohn remarks, when the muscles themselves are rendered opaque by immersion in spirit. Each band is again subdivided, but less distinctly, into a right and left portion; so that in fact the muscular apparatus might be described as consisting of four bands, a dorsal and an abdominal on either side. These muscular bands are composed of long transversely striated fasciculi resembling those of insects.

The disposition of the muscular apparatus would indicate, as observation shows to be the case, that the movements of the animal are chiefly those of flexion and extension in the transverse plane of the body, and consequently that the *Sagitta*, as was observed by Quoy and Gaimard, swims like a Cetacean by the horizontal blows of its caudal fin upon the water.

The *Nervous system*, in *Sagitta bipunctata*, may be described as consisting of two principal ganglions, one situated on the dorsal aspect of the head, the *cephalic ganglion*, and the other on the ventral aspect of the trunk, the *ventral ganglion*. The one consequently is above the œsophagus, and the other below it,—supra and sub-œsophageal ganglia. These ganglia—which, as well as the nervous trunks, lie immediately beneath, and in close contact with the integument—are mainly composed, as in other instances, of ganglionic cells, but in the ventral ganglion there appears to be a certain amount of white nervous matter in the centre (fig. 8, *h*).

The cephalic, or supra-œsophageal ganglion (fig. 7), is situated in the mesian line, a short distance from the anterior

* L. c., p. 6.

extremity of the head. It is of a more or less quadrangular form and flattened, in large specimens measuring about $\frac{1}{4}$ mm. in length. Three pairs of nervous cords proceed from it.

1. An anterior (fig. 7, *b b*) which curves outwards, and then backwards towards the process of the head upon which the buccal hooks are placed, to terminate according to Krohn, in the muscles by which the hooks are moved, close to which, he says, that each nerve presents a minute ganglionic enlargement from which several filaments are given off to be distributed to the muscles.

The posterior pair of nerves arising from the cephalic ganglion (fig. 7, *c c*) pass backwards, in a divergent direction, and terminate in a rounded ganglionic mass, in the centre of which the eye (fig. 7, *k*) is, as it were, imbedded. These optic ganglia, according to Krohn, are composed of distinct ganglionic cells; but it would appear from Mr. Huxley's observations, that the optic nerves, as they may be termed, also exhibit a smaller ganglionic enlargement immediately before entering the optic ganglion (fig. 7, *l*). The optic ganglion and the eye lie in a special closed cavity in the integument of the head.

3. The third pair of nerves arising from the cephalic ganglion (fig. 7, *d d*) are given off from the sides of that body, curving backwards and downwards, so as to pass on either side of, and to get beneath the œsophagus, where they approach each other again, and becoming nearly parallel in the mesian line of the trunk, join the ventral ganglion. They constitute, therefore, what may be termed an œsophageal commissure.

The ventral ganglion (fig. 8) lies in the middle of the ventral surface of the trunk, also immediately beneath the integument, which is seen to be somewhat elevated by it when the animal is viewed on the side. It is situated between the head and the lateral fins, though rather nearer to the latter. It is of an elongated, oval form, and in full-grown individuals about $1\frac{1}{2}$ mm. long. There may be distinguished in it a lighter-coloured nuclear or medullary substance (fig. 8, *h*), which occupies a central tract, and a darker-coloured, coarsely granular cortical layer, composed apparently for the most part of ganglion-globules. Four principal nervous trunks proceed from this ganglion: an anterior pair (fig. 8, *d d*), which are continuous with the lateral trunks given off from the cephalic ganglion (fig. 7, *d d*), and constitute the œsophageal commissure; and a posterior, (fig. 8, *f f*), which run directly backwards, slightly diverging from each other. These trunks are, upon the whole, stronger and rather shorter than the anterior pair, inasmuch as, according to Krohn, they do not extend much beyond the anterior pair of lateral fins. He states that each trunk terminates

in a sort of *cauda equina*, composed of numerous minute nervous twigs. From the sides of the ventral ganglion, and according to Krohn, from the nervous trunks also, are given off numerous nerves in rapid succession, which, according to the same observer, curve upwards towards the dorsal surface of the trunk, subdividing into numerous twigs, which anastomose, and thus constitute a very intricate plexus beneath the integument. The latter part of this statement may perhaps be erroneous, but at any rate there is no doubt of the fact, that numerous small lateral branches are given off, apparently symmetrically, from the sides of the ganglion itself, as shown in fig. 8.

The Head.—This portion of the animal is distinctly separated from the trunk, and is surrounded by a sort of membranous hood, which is capable of being drawn backwards over it. The upper surface of this hood is level with that of the trunk, whilst the lower forms a plane inclined from above, and anteriorly downwards and backwards. When fully expanded, the hood, except inferiorly where it presents, in the middle line, a longitudinal opening for the mouth, appears to envelop the entire head ; when retracted, the head is exposed, particularly on the sides, when the following parts are displayed. 1. On each side a series of curved pointed hooks, (fig. 3, *c*), which, when the hood is expanded, close from either side of the mouth. The number of these hooks does not appear to be very constant, and the anterior hooks are usually shorter than the others. 2. Besides these larger buccal hooks there will be observed, at the anterior extremity of the head, two curved series of smaller denticles (fig. 3, *a*), one behind the other on either side.

On each side the inferior surface of the head presents a large, rounded eminence, apparently composed of the muscles by which the buccal hooks are more directly moved, and between these buccal lobes is situated the oval opening in the form of a longitudinal slit or fissure, which is crossed posteriorly by a kind of fimbriated border, stretching across from one buccal lobe to the other (fig. 3, *b*).

The pharynx or œsophagus commencing at this point is a short tube with thick muscular walls, a little larger in diameter than the intestine, and extending but a short distance beyond the junction of the head and trunk. It is bounded on either side by the buccal masses above noticed. On the upper surface of the head, on either side, and pretty close to the median line, will be seen the "eyes," (fig. 7, *k*). These organs are composed apparently of a mass of black pigment, around the margin of which will be noticed clear points, or *corneæ*,

which, according to Mr. Huxley, are disposed in three distinct sets. As has been before stated, the eyes are lodged in the upper surface of the optic ganglia, and contained together with them in special cavities excavated in the integuments of the head.

2. *Trunk.*—This portion, which constitutes the principal part of the animal, is an elongated hollow sac containing the muscular hands above described, the intestinal canal and termination of the œsophagus, together with the ventral ganglion and its branches, and the ovaries which are situated posteriorly.

The intestinal canal, which commences at the termination of the œsophagus, is a simple, straight, somewhat compressed tube, extending from this point to the junction of the trunk with the caudal portion, where it makes a rather abrupt curve downwards, becomes contracted, and terminates in the anus, which presents the form sometimes of a rounded aperture, sometimes more that of an elongated slit, but in either case projecting beyond the surface. The walls of this simple tube are composed principally of a layer of annular fibres, strengthened on the upper and under sides by a narrow band of longitudinal fibres, which, according to Krohn, are situated external to the annular. The tube is lined internally by an epithelium, composed of elongated prismatic cells, furnished, perhaps throughout, with long vibratile cilia. It is supported in its place above by a continuous median band, and below it is held by numerous slender, usually branched threads, disposed in a line corresponding to the band above. The perigastric cavity is thus imperfectly divided, as it were, into two lateral compartments.

The intestinal canal is generally empty, but in a few instances Krohn has seen in it fragments of minute fish and crustacea, and in some cases portions of other *Sagittæ.*

The "caudal portion," and the ovaries, constitute the *sexual apparatus*, which will now be described.

1. The female portion of this apparatus consists of two organs, which are situated in the posterior part of the cavity of the trunk, on either side of the terminal portion of the intestine (fig. 4, *a*, *a*, fig. 6). These organs, which may be termed ovaries, in the mature state, are often of considerable size, extending even beyond the upper pair of lateral fins. They are elongated sacs, which are attached by a longitudinal band to the lower wall of the trunk. Inferiorly the ovary curves abruptly upwards and outwards, forming a sort of short oviduct, which opens externally between the upper muscular band and the base of the posterior pair of lateral fins. In the

outer portion of each ovary is a dense granular tract (fig. 6, *a*), the remainder of the cavity being occupied by a more finely granular stroma in which the ova are developed, attached at first by short pedicles to the placental tract. In the outer portion of this tract runs a slender cæcal canal, which may be traced close to the opening of the oviduct (fig. 6, *b*). This canal, which was first noticed by Wilms (l. c. p. 13, fig. 10), is regarded by Krohn (Wiegm. Archiv. 1853, p. 269), as a *receptaculum seminis*, seeing that it is occasionally found to be filled with actively-moving spermatozoa. According to Wilms and Huxley, the canal is lined with cilia, but Krohn is of opinion that this appearance of cilia is due to the presence of the motile spermatozoids. The *ova* (fig. 6, *c*) present no peculiarity, except that Wilms and Krohn concur in stating that a germinal spot is never observed in the comparatively large germinal vesicle.

2. *The male apparatus.*—The caudal portion of the animal (fig. 1, *d*) is divided by a vertical, longitudinal septum, into two perfectly distinct compartments. These compartments may properly be termed the *testes*, as it is them that the development of the spermatozoa appears to take place, which is thus described by Wilms (l. c. p. 13). In younger individuals, each compartment contains a greater or less number of vesicles of various dimensions, some spherical, others of irregular form, elongated, and ovoid. At first sight they seem to be filled with a sort of granular substance, but when a little larger, are plainly seen to contain minute spherical cells. In animals nearer maturity, besides these cysts, there will also be noticed cells in which, upon the addition of acetic acid, a nucleus is plainly visible. From these aggregations of cells (fig. 9), which are always somewhat less in size than the cysts above noticed, the spermatozoa are developed. At a certain period, slender filaments are seen to proceed from them, causing the appearance as if the cells were beset with spines, whilst others present the appearances represented in fig. 12, *a*, *b*, indicating a further stage of development. The central cellular mass (shown at *a*, fig. 12) gradually diminishes in bulk as the filamentary portions become more and more developed (fig. 12 *b*), and gradually disappears altogether, nothing remaining but bundles of spermatozoids attached to each by their heads. These bundles eventually break up into separate spermatozoids. The mature spermatozoid is a long filament, slightly enlarged at one extremity, beyond which, however, the point is usually prolonged in the form of a very delicate short thread (fig. 11).

A remarkable circumstance observable in the spermatic cavities of *Sagitta*, is the continual cyclosis performed by their

contents.* These will be seen constantly ascending on the outer, and descending on the internal wall or septum in the directions indicated by the arrows in fig. 4. The cause of this motion is stated by Krohn to depend upon the presence of scattered cilia in the posterior part of the cavity.

The spermatozoids thus formed make their exit from the cavity in a very curious mode. On each side of the caudal portion will be observed a projection, (figs. 1 and 4, *e e*,) which may, perhaps, be regarded as a sort of ejaculatory apparatus. These processes are hollow sacculi, which open externally by a rounded orifice situated at the upper end, and communicate with the interior of the compartment to which they belong, through a canal excavated in the integuments of the caudal portion. If, as Krohn observes, one of the seminal compartments be laid open by a longitudinal incision on the under surface, and the contents carefully removed, an opening surrounded by a raised margin will be clearly seen at a short distance from each ejaculatory sac. This orifice leads into the canal above mentioned, which runs along the corresponding border of the upper muscular band, making a slight curve posteriorly, gradually contracting in size, and finally opening in the cavity of the ejaculatory sac. The inner wall of these efferent canals, as well as of the external sac, is lined with an actively vibrating ciliated membrane.

With respect to the mode in which the spermatozoids come in contact with the ova nothing is known, though it would seem, if Krohn's observation above related, of the presence of spermatozo ain the cæcal canal contained in the ovary be confirmed, that they must make their entrance in some way into that organ. It is more probable, however, that the ova are impregnated after extrusion; and that this is the case, is rendered the more likely by the circumstance that innumerable spermatozoids in the most active motion may occasionally be observed, swarming out of the orifice of what I have termed the ejaculatory sac (fig. 5). And it seems scarcely possible that these motile filaments should make their way spontaneously into the narrow and close opening of the oviduct, which they must do in order to reach the canal in question.

The *Sagitta* is obviously oviparous; but with respect to the further development of the ova after deposition, little is known. According to Krohn (Wiegm. Arch. 1853, p. 270), the vitellus consists of numerous cells containing an albuminous fluid, and in which he was unable to perceive any vitelline granules. It is surrounded by two membranes. The internal, which

* Krohn remarks (p. 13), that a similar movement of the spermatic globules is observed in the testicular vesicles of the Leech.

closely envelopes the vitellus, is thin and firm; the proper vitelline membrane, whilst the outer is much thicker, and according to him of a gelatinous consistence, swelling up rapidly when the ova escape into the surrounding water. At a later period it is sometimes absent, although the development is not, according to Krohn, by this interfered with. Mr. Darwin also (l. c.) assigns an outer envelope to the ovum, but it would seem that this envelope was of a firmer consistence than the one described by Krohn, since he states that it is ruptured soon after the commencement of partial segmentation of the vitellus, which undergoes its further development after it has thus escaped.*

Many species of *Sagitta* are described by different authors, but it would seem that considerable confusion still exists on this subject. One thing appears tolerably certain, viz., that the species common on the British coast, and which is the one here described, is, as before stated, very widely distributed in all seas from the north to south antarctic oceans. And it may well be supposed that superficial observation of specimens at different ages and of different sizes, may have caused an unnecessary multiplication of species.

Krohn, who considers that the number, position, and form

* In Siebold and Kölliker's 'Zeitschrift f. Wissens. Zoologie,' Bd. v., p. 15, is a short notice respecting the development of *Sagitta*, by C. Gegenbaur. He states, that the process of segmentation terminates in the production of an embryo of a rounded form, in which two kinds of cell-masses may be recognized,—one central, constituted of minute, and a well-defined peripheral layer, composed of larger cells. A depression is now formed at one point of the surface, which gradually advances to the centre, constituting the rudiment of the intestine. The embryo now appears to increase in length, in consequence of which, since it completely fills the cavity of the *ovum*, it becomes bent, and is ultimately coiled in a vermiform fashion. The cavity of the trunk may be distinguished, traversed by the intestine, which forms, as it were, a vertical septum; but, besides this, no other internal organs are apparent. At this period the embryo often moves, and on the addition of acetic acid the muscular bands in the trunk are visible, completely formed, and exhibiting the fine transverse *striæ*. The fins arise as simple lateral outgrowths of the body. In this condition the animal leaves the *ovum*, about $\frac{3}{4}'''$ in length, and already presenting in all respects the character of the full-grown *Sagitta*. The other organs, consequently, are not developed until after the animal has quitted the *ovum*. In the entire course of development, many stages of which, particularly those which succeed complete segmentation, are very difficult to be understood, *cilia* never make their appearance.

If the anatomy of this creature had not satisfactorily shown that it belongs neither to the Pteropoda, nor to the Heteropoda—this would have been rendered certain by its mode of development, which does not accord in any respect with the Molluscan type. What the real position of *Sagitta* is I will not determine.

of the lateral fins will afford most useful diagnostic characters, describes the following species:—

1. *S. multidentata* (Wieg. Arch. 1853, p. 271, Plate 12, fig. 2).—Which in habit closely approaches the *S. setosa* of Wilms (our *S. bipunctata*). The posterior fins are longer and wider than the anterior, which extend in front to about the anterior third of the body. The number of hooks is from 9 to 11. That of the denticles in front of the mouth (fig 3, *a*), is in the anterior row from 5 to 8, and in the posterior from 12 to 13.

He notices another form closely resembling the above, but characterized by the existence of a horny, toothed ring around the orifice of the ejaculatory sacs.

2. *S. serrato-dentata* (l. c. figs. 3 and 4).—Which appears to resemble the foregoing in nearly all respects, except in the conformation of the hooks, which are described as serrated on the inner edge for about half their length. The number of hooks is from 6 to 8 on either side. The denticles in the anterior row are never more than eight in number on each side, whilst in the posterior there are as many as 18 The bundles of rigid *setæ* are disposed symmetrically in eight lateral rows, four dorsal and four on the ventral aspect. It is a very small species, not exceeding 4½ m. in length.

3. *S. lyra* (l. c., fig. 5).—The caudal portion of the body very short and separated by a groove from the elongated trunk. The two pairs of lateral fins are apparently continuous with each other, and the anterior are much longer than the posterior, and extend far anteriorly. The number of hooks is 6 to 8 on either side; of the denticles, 7 in the anterior and 11 in the posterior series. The bundles of *setæ* are irregularly distributed over the surface of the body. It is a large species, attaining the considerable length of from 3 to 3½ centim.

4. *S. draco* (l. c., fig. 6).—The body of this rare form is short and thick, and invested for the anterior three-fourths of its length, by a very considerable layer of large, thick-walled cells. The caudal portion is very long, the trunk short, and the caudal fin of large size. The anterior pair of lateral fins is wholly wanting, and the pair corresponding to the posterior fins of other species do not extend beyond the caudal portion of the body. The species is remarkable also for the existence of two lateral and opposite bundles of numerous, very long, freely-floating filaments, seated upon special eminences, which again are placed upon the cellular layer surrounding the anterior part of the body. The filaments are of soft consistence, ligulate, and constituted of parallel longitudinal fibrillæ. There are ten hooks on either side; eight

anterior denticles on each side and 18 posterior. The bundles of rigid *setæ* are scattered irregularly over the surface. The only individual met with by Krohn was one centimetre in length.

Other species described by authors are—

5. *S. cephaloptera* (Busch, l. c., pl. xv., fig. 2).—Distinguished by a radiated disc on the anterior part of the trunk, and two tentacular processes on the sides of the head.

6. *S. rostrata* (Busch, l. c., fig. 7).—Distinguished from *S. setosa*, Wilms, by the presence of a large rounded eminence on the anterior part of the head, which Krohn imagines may be caused in a young specimen of a *Sagitta* by the cephalic ganglion.

7. *S. bipunctata*, Quoy and Gaimard, which we regard as identical with—

8. *S. setosa*, Wilms, the species here described, and probably the parent of other species, among which perhaps may be enumerated those named by D'Orbigny (Voyage dans l'Amerique Meridionale, tom v., p. 14, Pl. 10) according to the number of their fins, as *S. diptera*, *S. triptera*, and *S. hexaptera*. If all these really belong to *Sagitta* at all, which, in the absence of farther information than that given by D'Orbigny, may be regarded as doubtful, *S. hexaptera*, at any rate, may be considered identical with *S. bipunctata.*

With respect to the systematic position of *Sagitta*, very considerable difficulties arise in the determination of it. Mr. Huxley (l. c., p. 77) remarks that "*Sagitta* has been placed by some among the Mollusca, a view based upou certain apparent resemblances with the Heteropoda. These, however, are superficial; the buccal armature of *Sagitta*, for instance, is a widely-different structure from the tongue of *Firola* to which, when extended, it may have a distant resemblance." "There appears," he says, "much more reason for placing this creature, as Krohn, Grube, and others have done, upon the annulose side of the animal kingdom; but it is very difficult to say in what division of that sub-kingdom it may most naturally be arranged." After surveying the points of resemblance and difference between *Sagitta* and the nematoid worms and certain Naiadæ, Mr. Huxley concludes by observing "that the study of its development can alone decide to which division of the annulose sub-kingdom *Sagitta* belongs; but that until such study shall have demonstrated the contrary, he stated his belief that *Sagitta* bears the same relation to the Tardigrada and Acaridæ that *Linguatula* (as has been shown by Van Beneden) bears to the genus *Anchorella*, and that the

young *Sagitta* will, therefore, very possibly be found to resemble one of the Tardigrada, the rudimentary feet with their hooks being subsequently thrown up to the region of the head as they are in *Linguatula*."

Krohn, with much hesitation, is inclined to regard it as belonging to the Annelid group, with which it would certainly at present appear to exhibit a very probable relationship.

On the Magnifying Power *of* Short Spaces *illustrated by the* Transmission *of* Light *through* Minute Apertures. By John Gorham, M.R.C.S.E., &c.

Having described in the former papers the appearances observable when pencils of light from small *circular* apertures are partially intercepted by certain opaque or transparent objects of definite shape and size; and having shown that whether shadows or illuminated spaces are thus used, they serve to exemplify the magnifying power of short intervals existing between the organ of vision and the object to be examined, inasmuch as they occupy some *position in space*, and have a certain *form*, qualities which pertain to them in common with all substances appreciable by the sense of sight, we proceed to notice the phenomena which result when exceedingly *narrow linear apertures* are substituted for those of a circular form. In conducting these investigations it was not unreasonable to suppose, à priori, that if the size, the quality, and the position of the object to be examined, the direction and the intensity of the light which was used, the sensitiveness and immediate response of the pupil of the eye to the minutest variation in the quantity of light impinging on the retina, and the refracting qualities of the transparent portion of the visual organ, were each and all taken into account, so that a nice and delicate adjustment of the eye to the light, and of the light as well as of the size of the objects to the eye could be insured, appearances perhaps beautiful, doubtless uncommon, and certainly interesting to the physiologist might be fairly anticipated. Such anticipations, have been so far realized as to present a strong inducement to prosecute the subject with a legitimate prospect of still greater success.

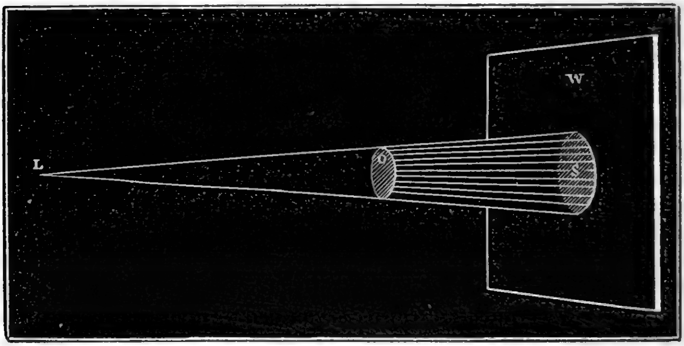
It is obvious that the phenomena which have occupied our attention are chiefly due to the formation of shadows. For when a divergent pencil of light proceeding from a small circular perforation in a card falls upon the eye, and when a small object either transparent or opaque—a transparent cross on a black ground, or a black cross on a transparent ground,

for instance, is allowed to intervene; it is evident that a shadow of the cross in the latter case, and an illuminated space equivalent to the shadow in size and shape, in the former, is portrayed on the retina of the eye.

The same kind of phenomena result even if no artificial body be interposed between the eye and the source of light, the pupillary aperture in this case constituting the transparent space, and the *iris* the blackened margin which gives it outline, so that those rays which are not intercepted by this curtain, pass onwards and ultimately form a picture of the pupil itself at the bottom of the eye.

When an opaque object is held either in a beam of light (bundle of parallel rays), or a pencil of light (rays proceeding from or towards some point), it intercepts a portion of the rays, and the space behind the object is in darkness. This dark space is called the *shadow* of the object. Thus in figure 1, if the luminous body L emits a pencil of light which is stopped in its passage towards the screen by a round piece of blackened pasteboard, O, the dark space between this and the screen, W, is the shadow.

Fig. 1.



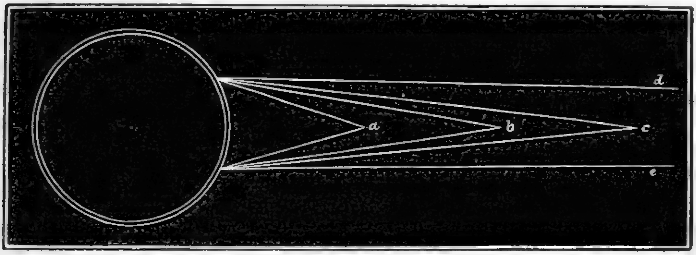
A shadow may be received on a screen held near the object, when its outline will be similar to that of the body by which it is cast. Thus the shadow of the circle O (fig. 1,) is projected as a circle at S, on the white screen W.

The *breadth* of a shadow depends on the direction and disposal of the rays of light when they are stopped by the opposing body. These may be *parallel*, *divergent*, or *convergent*. In the remarks which immediately follow, I shall merely embody so much under each of these heads as relates to the subject of our present disquisition.

With respect to *parallel* rays it is to be observed, that the farther the luminous body is from an object, the less divergent

are the rays which fall from it upon the object; or the more nearly do they approach to being parallel. "From *a* (fig. 2) there is much divergence, from *b* less, from *c* less still, and

Fig. 2



rays from a greater distance, as those represented by *d* and *e*, appear parallel. If the distance of the radiant point be very great, they really are so nearly parallel, that a very nice test is required to detect the deviation. Rays, for instance, coming to the earth from the sun, do not diverge the millionth of an inch in a thousand miles. Hence when we wish to make experiments with parallel rays, we take those of the sun."* When such rays therefore are intercepted by an opaque body, the breadth of the shadow, for we are not now speaking of its length, is equal to that of the substance. The student in perspective, is aware of this fact, and the fine effect of a good landscape painting is to be referred in part to the strictness with which this relation is observed by the artist.

If the rays are *divergent*, as when the light-emitting body is very small, a mere point, the shadow is larger than the object. Thus if L (fig. 1) be the luminous body, and O the obstacle, the circular figure, S, on the screen, W, being a cross section of a shadow which is continually increasing in breadth, is larger than the object O. "The shadow of a hand held between a candle and the wall is gigantic; and a small pasteboard figure of a man held in a divergent pencil of light, and near its source, throws a shadow as big as a real man. The latter fact has been amusingly illustrated by the art of making phantasmagoric shadows." Divergent pencils are easily procured from a pin-hole, a taper, a street lamp, a carriage lamp, &c.

When a *convergent* pencil of rays is obstructed by an opaque body, the shadow is smaller than the object, and if not received on a screen, would taper to a mere point. This is true of the shadows of all the planets, and of the earth, because they are less than the sun. It is exemplified when the moon

* See Arnott's 'Elements of Physics.'

falls into the earth's shadow, and becomes eclipsed, or still better in a solar eclipse, when the moon being at her average distance from the earth, the shadow but just reaches the earth's surface. Thus if S (fig. 1) represent the sun, and O the moon, that portion of the earth situated at L is in its shadow.

The *shape* of a shadow is regulated by the distance between the object and the screen on which the shadow is received. If this be great, the shadow bears no very definite relation in form to that of the object. On the contrary, it is a mere irregular darkened space, the boundaries of which are ill defined and the shape distorted. Thus a leaf at the distance of a yard or two from a wall, will, in the sunshine, give a shadow of indefinite outline, having a round instead of an angular edge: a leaf at a greater distance will produce a mere dimness, with an outline scarcely distinguishable. Instances of a like kind are afforded when the sun's rays are obstructed by the topmost branches of a tree, or the summit of a tower, or by the intervention of passing clouds, which in their passage through the atmosphere contribute so much to the beauty and variety of the natural landscape, and are amongst those fleeting appearances which elude the vigilance of the pencil.

When the screen is at a great distance from the obstacle, as well as from the source of light, the shadow so far from taking the shape of the obstacle, will resemble that of the luminous body. Thus the shadow of an *irregular* body placed in the sun's light is *circular.*

If on the other hand the object is brought to within a short distance of the screen, its shadow is so clearly defined as to be directly recognized as an exact *fac-simile*, in shape, of the body itself. A leaf nearly close to the wall casts a shadow of a leaf.

"These observations regarding shadows are applicable to the illuminated space formed on a screen by making the sun's light pass through an aperture." This will be obvious, on reflecting, that if a shadow or darkened space be well defined, the adjacent, illuminated space must be equally so, and *vice versâ.* For these are contrasted conditions, each of which causes the other to become visible. Neither light alone, nor darkness alone, but only contiguity of both will enable us to appreciate form. Hence light and shade are not only pleasant to the eye, but both are absolutely necessary for the distinguishing of one object from another. For this reason, probably, the visual organ is ever intuitively on the search for contrasts either of light, shade, or colour.

"When the screen is near the aperture, the illuminated portion is similar to the opening; but when the screen is suffi-

ciently distant, it is similar to the luminous body. The interstices between the leaves of trees are so many small irregular apertures; hence the cause of the numerous small bright circles seen in a sunny day in the shadow of a tree, or still more distinctly in that of a grove."*

These simple laws which govern the projection of shadows, and which have been seen to adapt themselves to individual cases, may be easily verified. It is by their judicious combination, however, that we discover the best method of throwing large and well-defined images of small, near objects upon the bottom of the eye, which indeed constitutes the main design of our inquiry. Thus of the three modes of illuminating the object which have been enumerated, that is obviously the best suited to our purpose which casts the broadest shadow. A *divergent pencil of light is therefore chosen.* In the next place he position of the screen demands attention, for on this, as we have seen, depends the definition as well as the enlargement of the image. Now in the investigation of small, near bodies, the screen cannot possibly be brought too close to the eye; indeed it is better to dispense with all artificial substitutes, and to use that kind of screen only which nature has provided. That is to say, the *retina* of the eye itself. This has accordingly been adopted.

Again, recollecting the impossibility of distinguishing outline at all, except by contrast,—a mass of shade bounded by light, or light by shade,—definite contiguous portions of the retina are simultaneously affected with such impressions by using a darkened tube to exclude the light, having small inlets of determined size to regulate its admission at one end, and openings to secure its transmission and exit at the other. In this way, light and dark spaces are brought into direct contiguity with a well-defined line of demarcation between them. *Thus small objects are appreciable.*

But, moreover, a shadow, like its substance, appears larger as it approaches the eye; and the amount of enlargement is regulated by the same law. Hence the one is equivalent in this respect to the other: and as a shadow can be projected directly in front of the eye, and received as an image, it is thereby much magnified; nevertheless at such short distances, both shadow and substance, by any other process, would prove invisible.

Here, then, we have within our reach the combination of elements which appear necessary for examining small objects, at very short distances from the eye; namely:—*A darkened retina, a diminutive object less than the pupillary aperture, held*

* See Chambers' 'Optics,' p. 14.

close in front of the eye, and a small divergent pencil of light. From which it results, *that the object when held in this pencil, intercepts a portion of the light, and so casts a shadow greater than itself, which shadow is rendered visible by contrast, still further magnified by proximity, and eventually forms a visible image at the bottom of the eye.*

This principle of opposition or dissimilitude of shade, as well as of colouring, called *contrast*, a term in very general use in painting, is of universal application, because it contributes not to the beauty only, but to the visibility of all objects. Whether these opposite and contiguous colours or shades are seen at the same time, and that this gives rise to the effect of which we are all sensible, as is generally supposed, or whether it results from attentively looking at the one and then at the other in rapid succession, as was insisted upon by Sir Charles Bell, it is not our province now to inquire, although there are reasons for believing that both of these theories are correct, and that the former holds good for minute objects near to the eye, while the latter applies to larger ones at greater or common intervals. Dismissing hypothesis, however, we know that with respect to bodies viewed at ordinary distances, if a white figure be delineated on a white ground, or a black figure on a black ground, neither is visible; in the first there is no shade, and in the second no light, consequently there is no contrast. But the slightest variation of shade in the figures in relation to their respective grounds, is sufficient to render each of them definite. Hence the effect of a well-executed engraving, in which, although no colour is introduced, but merely white and black to imitate light and shade, the appearance is natural and satisfactory.

Two simple experiments will serve to show the importance of attending to contrast with respect to the examination of very near objects. By the first it is seen that *although a well-defined image is known to be certainly received on the retina, it is invisible when the retina and it happen to be equally illuminated.* For this purpose, let perforations with a needle, the tenth of an inch apart, and arranged in the form of a circle of about a quarter of an inch in diameter, be made in a piece of blackened cardboard (fig. 3). When brought close to the eye, these apertures appear as a ring of luminous circles (fig. 4), the remaining part of the retina being in darkness. If now a round piece be cut out from the centre of the first card, a portion as large, for instance, as that which is traced in outline, but not actually excised in figure 3, so as to admit light through the very middle of the perforated circle; it will be found that while the discs are known to be still received on the

retina of the eye as circles, inasmuch as the perforations remain intact, and their position unaltered, they are not perceived as such, because the surface at the bottom of the eye on which the inner half of each falls is illuminated. Hence they appear as semicircles (see fig. 5).

Fig. 3.

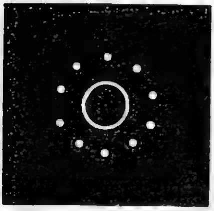


Fig. 4.

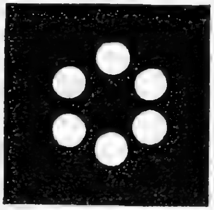
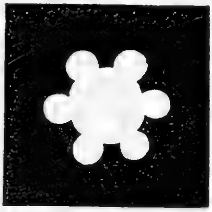


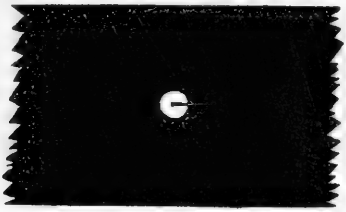
Fig. 5.



From which it is manifest, that however well defined an object may be, and however assured we may feel that its image is actually portrayed on the bottom of the eye, it is not recognised unless the contiguous surfaces are oppositely affected with respect to light and shade.

The second experiment is the converse of the last, and goes to prove that *an image is visible only when the retina of the eye and the object are unequally illuminated.* Let that portion of a common sewing-needle which contains the eye be mounted on a slip of glass as if for the microscope; and let the paper with which it is covered, have a very small circular aperture through which to examine it, thus (fig. 6):

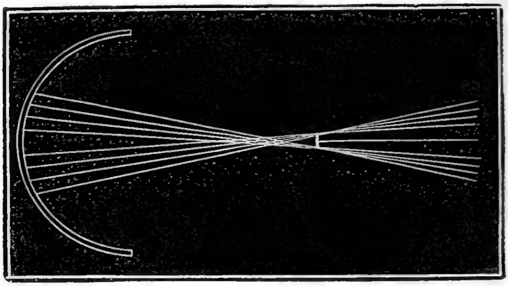
Fig. 6.



On holding the object close to the naked eye, it is found to be altogether invisible. Nothing is seen but vacant space. It is matter of certainty, however, that the front rays are intercepted, and that a shadow of the needle is therefore really formed, but before reaching its destination, lateral rays stream into the eye in all directions, which neutralise the shadow, and so nothing is seen (fig. 7).

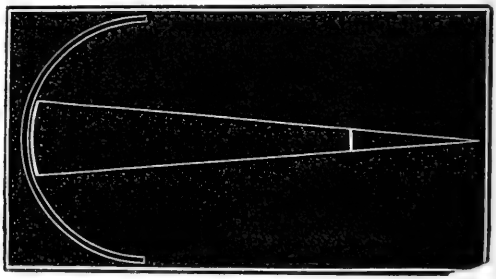
But when these lateral superfluous rays are excluded by using a divergent pencil of light only, as in the *diascope*, the shadow becomes visible; and not only is the exposed portion of the body of the needle seen, but its eye is well defined, and both appear considerably magnified (fig. 8).

Fig. 7.



Hence we may safely assume that all small bodies, whether transparent or opaque, are undistinguishable when held *close* to the naked eye, in broad day-light, or diffused light of any kind, but that if it were possible to distinguish them while in this position, they would appear magnified; and moreover, that this may actually be effected in many instances by the artificial contrivances to which we have been endeavouring to direct attention.

Fig. 8.



If a single object be retained in a given position before a screen, it will intercept the rays emitted from any number of separate luminous bodies, or sources of light, situated in front of it, and so cast as many shadows. In this way the shadows are *multiplied*. Thus if a finger be held within an inch or two of the wall, and a number of tapers at as many yards, the pencils of light from the tapers crossing the finger in different directions, and being intercepted by it, an equal number of shadows are cast on the wall at intervals, related to the position of the

taper. And if an opening of given shape were substituted for the opaque object, as many illuminated spaces would be projected on the wall instead of the shadows.

This is effected on a small scale in the *diascope*, where small perforations which admit the light are substituted for the tapers, transparent designs on glass for the object, and the retina of the eye for the screen on the wall.

Beautiful combinations on a large scale might be projected on an extended surface by the multiplication of shadows, but it is not our purpose to examine bodies at ordinary distances.

Hitherto but few experiments have been instituted for the purpose of showing what kinds of images are produced without a lens by bodies held close in front of the eye. It is not likely, therefore, that all the necessary conditions shall be devised until more care and attention shall have been bestowed on this interesting branch of optics. Those which have been mentioned in the former papers, and are resumed in this, may possibly prove sufficient to provoke inquiry, inasmuch as they are based on legitimate conclusions from the known laws of optics, and are confirmed by experiments.

Small circular, as well as elongated openings for the transmission of light were used by Grimaldi, Newton, Fresnel, and Frauenhofer for investigating the phenomena, which light produces, when passing near the edges of bodies, a branch of optics which is called the *inflexion*, or the *diffraction* of light.

A divergent beam of light was obtained by causing the sun's rays to pass through one of these apertures, and it was ascertained that the shadows of all bodies whatever, held in this light, were not only surrounded, but encroached on by fringes of colours.

The experiments themselves were instituted for the purpose of ascertaining the magnitude, form, colour, and number of such fringes, when examined either by common or by homogeneous light.

The aperture, moreover, was held six feet or upwards from the eye, and the fringes were seen either by throwing them on a smooth white surface, where they could be examined with the naked eye, or by looking at them with a magnifying glass, in which case their peculiarities could be more carefully investigated.

According to Sir David Brewster, this curious property of light was ably and successfully investigated by Fresnel, but the finest experiments on this subject are those of Frauenhofer.*

* See Sir David Brewster's 'Optics,' Cabinet Cyclopædia; also Herschel's 'Treatise on Light,' § 735; also Edinburgh Cyclopædia, art. 'Optics,' vol. xv., p. 556; also 'Elements of Natural Philosophy,' by Bird and Brooke.

The experiments illustrative of these curious phenomena in which the light becomes bent into hyperbolic curves when passing near the edges of bodies, present nothing in common with those which form the subject of the present paper, in which the short space which is caused to intervene between the eye and the light precludes the possibility of detecting the coloured fringes, supposing indeed that these were the objects of which we were in search. The only point of resemblance between them consists in the minuteness of the apertures through which the light is admitted, and this serves to show that by the same simple means different ends may be accomplished. The mere peeping through a pin-hole without some definite purpose,—some object to be examined,—some particular theory to be investigated, were indeed a childish occupation. It is more than probable that some of the followers of Newton were not much better engaged when we find the celebrated Goethe afterwards using the words, *si per foramen exiguum*, somewhat tauntingly in reference to the fact of their so frequently introducing this term into their writings.

The curious figures now about to be described, and which are produced by the transmission of light through minute *narrow apertures*, although related to those which have been shown to result from mere perforation, contrast with them, nevertheless, in several important particulars, of which not the least striking, is the production of quadrangular planes which are formed when the light is partially intercepted during its passage towards the eye, and which when multiplied by increasing the number of lines which produce them, appear to fall together at their edges, and so to resemble hollow semi-transparent figures of considerable beauty.

It may not be withheld, however, that this part of our subject is, so far as I have yet proceeded, circumscribed within narrow limits, being restricted chiefly to the formation of images on the retina of the eye, of those solids known as parallelopipeds, with composite forms, resulting from the multiplication of the simple ones. The peculiar feature in the experiments, consisting not so much in the novelty of the forms themselves, as in their mode of production.

We proceed to consider the phenomena which light presents when introduced through a narrow aperture held at a short interval of an inch or two from the eye.

When an exceedingly small transparent space or aperture*

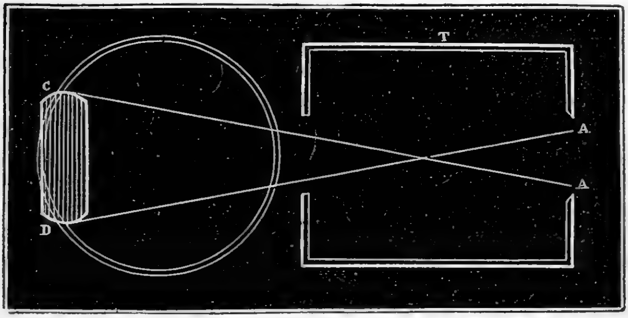
* Lines for this purpose may be drawn on glass, or cut through tin-foil. When the former process is adopted, a small round disc of Indian ink is laid on a circular piece of very thin glass, such as is used for the cover of microscopic objects, and which may be procured of any microscope maker.

made on glass, or in tin-foil, is held at the end of a darkened tube about two inches long, and examined by placing the eye at the opposite end, and looking either at a white cloud or a window blind on a sunny day, or at a lamp with a ground glass shade, it appears altered in *size*, *shape*, and *transparency*.

In order to illustrate this, and to give an idea of the image thus formed on the retina of the eye, let AA (fig. 9) be one of these apertures fixed in the end of a darkened tube T, and let AC, AD be rays of light admitted through it. This light will diverge in lines AC and AD, and form an image CD at the bottom of the eye.

If the same aperture be removed a few inches farther from the eye, it presents nothing remarkable, and in no wise differs in appearance from what we know to be its real form, namely, a transparent line of exceedingly small dimensions. But if it be again made to approach the eye, it will appear, first, to be much magnified; secondly, to have lost its rectangular outline, and to become rounded at either extremity; and thirdly, to be traversed by dark bands which take a direction parallel to its long axis, as shown in figure 9.

Fig. 9.



These glass covers are sold by the ounce, and are cut into squares or circles of various sizes for the convenience of mounting. The Indian ink might be painted on the glass by hand; but, after having made several gross of such black discs, the author of these papers strongly recommends a little instrument which, although constructed for a totally different purpose, answers most admirably for this. It is the invention of Mr. Shadbolt, and is described and figured in the second edition of Quekett's 'Treatise on the Microscope,' p. 289. This instrument is nothing more nor less than a miniature horizontal turning lathe, which is worked by the finger, and by which, with the assistance of a camel's-hair pencil, the ink may be laid on in circles with the greatest nicety and expedition. When dry the narrow line is erased with a finely pointed and slightly moistened one-nibbed quill; or, what is better, a style of brass drawn along a flat ruler. When tin-foil is used instead of glass, it may be held on a piece of smooth flat lead; an aperture of the required size can then be cut completely through with the point of a penknife.

The magnitude of the image is of course due to the proximity of the object to the visual organ, the rounded appearance of its ends to the circular form of the pupillary aperture, while the dark bands are produced by *interference*. These phenomena claim a more attentive examination.

That the apparent magnitude of the luminous space is so increased that the latter loses its linear form, and becomes a plane, is only another example indeed of the general law in optics, that all bodies, without exception, appear to grow larger as they approach the eye, and to diminish as they recede from it. But here an objection may be naturally raised by one who has not familiarised himself with such inquiries, or with the refracting powers of the eye. He finds from direct observation, opportunities for which occur daily, that remote objects do appear diminished in accordance with the law to which we have referred, and with respect to objects at such distances, he is inclined therefore to acquiesce in its correctness. But on holding a small body, a needle we will suppose, close to the eye, he is disappointed on discovering not only that it is not magnified, but that it is altogether invisible. Such an experiment has doubtless been performed by many, and from its failure it has been concluded, and not without an appearance of reason, that the body was held too near to the eye to be visible, which however is not the case, as we have endeavoured to show in a former experiment. But this very failure indicates the necessity of means to an end. For if having satisfied ourselves theoretically that the eye is endowed with certain capabilities, which we have reason to believe there is a possibility of developing; and if, on the application of certain known laws in optics, some definite figure which it was anticipated should certainly result, does not make its appearance, we are driven to the conclusion, that the failure is attributable to the experiment itself. A fresh trial, however, is perhaps crowned with success, and it is thus that we become possessed of new optical instruments, the value of which is directly proportionate to the importance of the laws they are designed to illustrate. For what are all optical instruments,

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The glass or tin-foil should now be mounted on a piece of cardboard of the required dimensions to fit the diascope, and having a hole about one quarter of an inch in diameter punched from its centre. For this purpose the thin tracing paper used by architects is the best, as it answers the double purpose of keeping the glass in its place, and preventing too much light passing through the apertures.

The dimensions of these apertures should be about the 1-15th of an inch by the 1-135th of an inch, or nine times as long as broad ($9 : 1 :: \frac{1}{15} : \frac{1}{135}$). These dimensions can be easily ascertained by a micrometer with the aid of a microscope.

but material combinations which serve to elucidate fundamental principles in optics by direct experiment?

When one of these apertures, only the 1-200th of an inch broad, is brought close to the eye, its apparent size is about two inches. This is easily proved by observing that the breadth of its image covers that of a line two inches long, held up for the purpose of comparing the two at an interval of ten inches, the distance at which we are accustomed to view ordinary objects in order to gain an idea of their supposed extension in space, and so to guess at their real magnitude. If this distance of ten inches were always preserved, and if surfaces whose real dimensions are required were always compared with a scale held at such a distance, the eye might become instructed to appreciate relations of magnitude with far greater accuracy than it has hitherto attained.

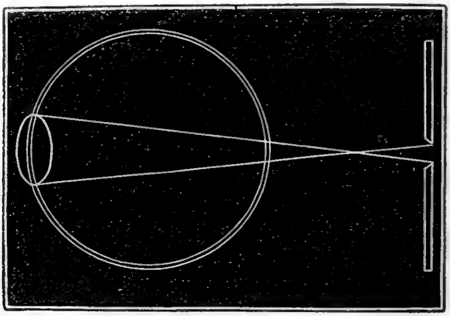
The comparison of the image of a very small object in close proximity to the eye, with that of any larger object at the usual distance for distinct vision, thus affords a correct method of measuring the apparent increased magnitude of all small bodies; and it cannot be too strongly impressed on the mind, that on looking through any aperture, whether small or great, it always *appears* as large as all we see through it. This has been happily expressed by an eminent writer. "If you shut one eye and hold immediately before the other a small circle of plain glass, of not more than half an inch in diameter, you may see through that circle the most extensive prospects, lawns and woods, and arms of the sea, and distant mountains. You are apt to imagine that the visible picture you thus see is immensely great and extensive; but it can be no greater than the visible circle through which you see it. If, while you are looking through the circle, you could conceive a fairy hand and a fairy pencil to come between your eye and the glass, that pencil might delineate upon that little glass the outlines of all those extensive lawns and woods, and arms of the sea, and distant mountains, in the dimensions in which they are seen by the eye."

Since this was penned, the fairy hand and the fairy pencil have both been actually discovered in the beautiful art of *photography*.

2. *The extremities of the aperture appear rounded or semicircular.*—We have seen how a circular perforation considered as a radiant point admits a divergent pencil of rays, the circular base of which forms a large round disc or image at the bottom of the eye (fig. 10). Now as a line mathematically considered is made up of a number of points, so a transparent line may be assumed to consist of a number of radiant points,

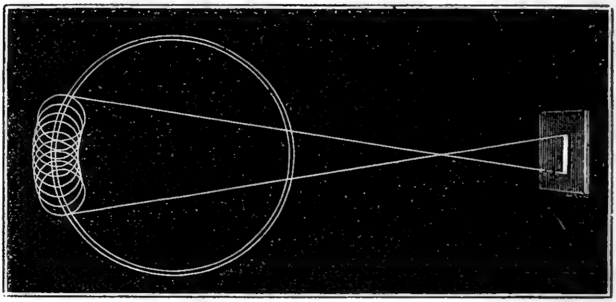
each of which lying side by side in a linear direction will produce exactly such a series of overlapping circles at the

Fig. 10.



bottom of the eye (fig. 11). Hence a small, narrow, transparent slit for the transmission of light when brought very near to the organ of vision, forms an image not of a line but of a plane rounded at either extremity.

Fig. 11.



3 *The area of the aperture appears to be traversed by longitudinal dark bands.*—"If we hold the hand between the eye and a bright cloud, or the ground-glass of a lighted lamp, and open the fingers so as to admit the smallest portion of light, we shall perceive similar dark bands intersecting the luminous space at regular intervals." * The explanation of this phenomenon is founded on the *interference* of light, which, according to the undulatory theory, takes place when the undulations meet in opposite phases; these being superposed produce darkness.

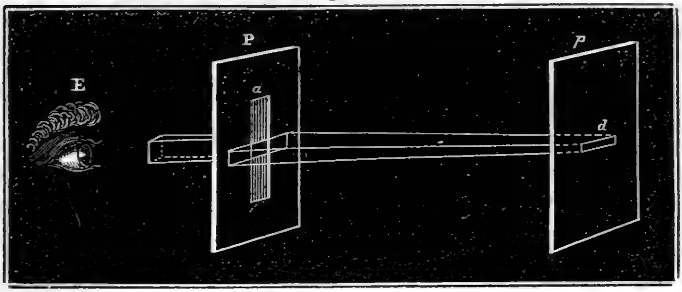
We have now to examine the appearance of bodies held close to the eye, and in the light admitted through small linear apertures such as we have been describing.

* See Woodward, on 'Polarized Light.'

Bearing in mind that the image of a linear aperture is not a line but a plane, and that this can be revolved by inserting it in the distal end of the *diascope*, it will be seen that if the object chosen for examination be a similar linear aperture held close to the eye we obtain a second plane, the first of which can be revolved in front of the second, and so the two can be made to intersect at any angle.

In order to illustrate this, let the planes P and *p* (fig. 12),

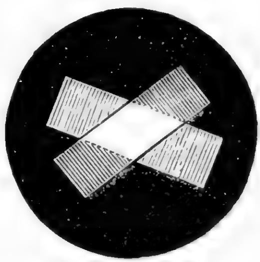
Fig. 12.



about two inches apart, be inserted at the ends of a darkened tube, and let a small linear aperture, *a* and *d*, be made in each of them. Now by revolving the plane *p*, the one aperture will intersect the other. When common diffused light is admitted through the further aperture *d*, the greater part is intercepted in its passage towards the eye at E by the plane P, but that which is transmitted will partake of the form of the luminous space produced by the intersection of the two. Thus when the apertures cross at a right angle, as shown in the figure, the image which meets the eye is a square, while it is rhombic at all other angles.

This may be further illustrated by cutting two oblong pieces, exactly similar in shape and size, from the lid and the bottom of a common pill-box. When the former is revolved upon the latter, the quadrangular planes to which we have referred are easily imitated (fig. 13).

Fig. 13.



Hence by holding two very narrow, linear apertures before the eye, and examining them by diffused light, all idea of mere linear extension is lost, and we obtain images of the square and all possible varieties of the rhomb.

It is worthy of notice that such planes do not differ in form

from the modifications which a square undergoes in obedience to the laws of *isometric* perspective; and it is obvious that if we are enabled to form any kind of rhombic plane at pleasure, by the mere revolution of one narrow transparent line upon another, we can by simply multiplying these lines multiply also the planes, which when united at their edges will present every appearance of a geometric solid.

And as a single line held close to the eye appears by intersection as a single isolated rhomb, so two or more such lines will form as many images, the relative position of which, as well as their number, can be regulated by that of the apertures which produce them.

If, for example, three fine transparent lines are projected in the form of an equilateral triangle, sufficiently small to be enclosed within the boundaries of a circle not bigger than the pupil of the eye (fig. 16), and if such an object be held close to the eye, and examined by the light admitted through the single aperture at the distal end, its image will be that of the triangular prism (see fig. 21, Pl. IV.).

On revolving the distal end of the instrument, which contains the single aperture, the prism will appear in a variety of aspects, four of which are shown in the figs. 21, 22, 23, 24, Pl. IV., in which the image is depicted as seen at each quarter of the circle.

In order to insure the proper effect, it is essential that each object (that which is held at the near or ocular extremity of the instrument) shall be mere transparent outline (figs. 14 to 20), in contradistinction to many of those which were examined by the light from the circular perforations, and which consisted of considerable surfaces of illuminated space.

A few of the outlines, which I have found to bring out the most satisfactory results, are given in the annexed figures (figs. 14 to 20).

Fig. 14.

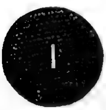


Fig. 15.

Fig. 16.

Fig. 17.

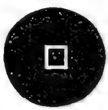


Fig. 18.

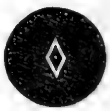


Fig. 19.

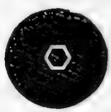


Fig. 20.

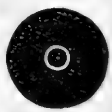


Fig. 14. The straight line.
15. Two straight lines meeting at 60°.
16. Three straight lines meeting at 60° (the equilateral triangle).
17. Four straight lines meeting at 90° (the square).
18. Four straight lines meeting at 60° and 120° (the rhomb).
19. Six straight lines meeting at 120° (the regular hexagon).
20. The circle.

The first of these objects is converted into the *rhomb* or the

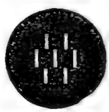
square, the second into two rhombs which are united at their edges, the third forms the *triangular prism*, the fourth presents an image of the *cube*, the fifth of the *rhombohedron*, the sixth of the *regular hexagonal prism*, while the seventh forms a very beautiful image of the *cylindrical tube*. All these figures appear hollow, and their terminal planes are filled in by the imagination.

Hitherto we have assumed the existence of a single linear aperture at the distal extremity of the instrument, and hence the production of a single image; but we can by increasing the number of the apertures multiply the images, just as when an object is held in the pencils of light proceeding from many simple perforations, and from the same cause.

The relative position and distance of the apertures will also regulate the disposition of the images; thus if they are arranged at regular intervals the images will be so also, and if in rays proceeding from a common centre the images will radiate in like manner. Several composite forms of considerable beauty are thus produced.

If, for example, a small hexagon drawn in transparent outline (fig. 19), be viewed in the light admitted through several alternating and equidistant linear apertures, thus (fig. 21), there will be seen the images of as many regular hexagonal prisms having the same relative position; and the resulting compound form will present a beautiful honeycomb appearance, as in the following figure (fig. 22).

Fig. 21.



If a transparent circle in outline (fig. 20) is substituted for the hexagon, the resulting form presents an analogous arrangement of cylindrical tubes, as in fig. 23.

Fig. 22.

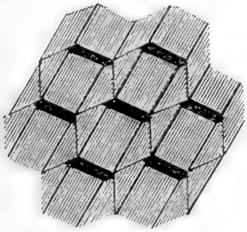
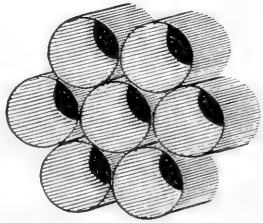


Fig. 23.



Were I not afraid of tiring the patience of my readers, I might here proceed to describe and delineate a considerable variety of beautiful figures, which are produced when the apertures at the most distant extremity of the instrument are tinted with different colours. The introduction of tints in

this way merely modifies and does not alter the results, and sufficient has been said in the former papers to show that the beauty of each image is much enhanced by the process. But I am not unmindful that, however interesting the results of these simple experiments with mere transmitted light may be to myself, it would be encroaching on the pages of the 'Microscopical Journal' to enter more into detail on this part of my subject. Neither does it appear desirable to attempt to give an air of importance to a set of phenomena which, saving that they constitute legitimate illustrations of the subject in hand, have at present scarcely more than their novelty and beauty to recommend them.

NOTES *and* OBSERVATIONS *on the* SAP-CIRCULATION *of* PLANTS.

By F. H. WENHAM.

SINCE my communication in the last number of this Journal, "On the Circulation of the Sap in the Leaf-cells of the *Anacharis Alsinastrum*," I have continued some investigations on non-aquatic plants, with the view of ascertaining the relation or analogy, that the phenomena of their circulatory movements display, towards the subject of my former paper, and to each other respectively.

I must, however, remark in the first place, that the examples have been examined in a very random manner, for I take up the microscope at uncertain periods, merely as a means of recreation, and make no pretensions to that order and system, which alone would allow the efforts of my pen, to find a place with those of a scientific and professed botanist. I am merely desirous of recording some facts which I believe have not before been noticed.

The movements of circulation are best seen in the hairs of plants, as the transparency and uniformity of their substance allows their internal mechanism to be very readily distinguished. I had commenced a list of the most remarkable, and after extending the catalogue to upwards of one hundred, I concluded that the difficulty was to find the exceptions, for hairs taken alike from the loftiest Elm of the forest, down to the humblest weed that we trample beneath our feet, plainly exhibit their circulation. Even hairs from the upper surface of a blade of common Couch Grass (*Agropyrum repens*) display the sap-movement with singular beauty and distinctness, considering the minuteness of the object; (the intermediate diameter being less than 1-1000th of an inch). The particles

may be seen traversing straight from the base towards the apex of the hair, and returning again by the opposite side.

The circulation in the hairs of the Groundsel (*Senecio vulgaris*) was first announced by Mr. Holland, as a discovery made by his triplet microscope, and it is a remarkable instance of what his instrument was capable of performing, for out of the multitude of vegetable hairs in which the sap-motion can be seen, I consider this to be one of the most difficult; for with our best compound microscopes, it requires careful management, and a trial of several fresh specimens before it can be shown satisfactorily.

Hairs that exhibit circulation may be taken from all parts of the plant, as the leaves, flowers, stalks, and fruit, and even from the ripening seed-pods as in the Snap-dragon (*Antirrhinum*) and White Mustard (*Sinapis alba*), &c. It is important that the specimens should be gathered from a portion of the plant, in a healthy and vigorous state of growth. The time is also of some consequence, the motion of the sap being generally most rapid about mid-day. The specimen must be examined as soon as possible, and the hairs detached without touching them, by tearing them off with a portion of the cuticle of the plant to which they are attached, by means of a fine-pointed forceps. If the hair itself is grasped the destruction of its vitality is the usual consequence. The object should be instantly placed in a *thin* glass compressor with clean water, using a good eighth object-glass and an achromatic condenser having a series of diaphragms. Daylight is infinitely superior to artificial illumination, and I have found it much preferable to use a right-angled prism instead of the ordinary plane mirror.

In cold dull weather, a well-known object will sometimes fail to exhibit its circulatory movements; in such a case, it may be called into activity by means of the natural stimulus of heat. In applying this the object need not be removed from the microscope, as a stream of hot air may be blown on to the upper or under surface of the thin covering glass, until the sap current is seen to move, by means of a metal blowpipe, or the stem of a tobacco-pipe, previously heated in the flame of a spirit-lamp. Some plants always require the application of an increased temperature, in order to show their circulatory movements. The hairs of the Helianthus are a good example of this.

In the hairs of the numerous variety of plants that display the sap-circulation, each species exhibits somewhat different and peculiar features, which may be considered, in a degree, characteristic throughout the plant; in some, single lines of

sap-currents extend the entire length of the cells or hairs, and in others they are divided into an irregular network of ramifications, which shift their positions with considerable celerity, the diversity of the phenomenon, perhaps, depending in some measure, upon the constitution and fluidity of the sap, for where this is rather glutinous the current traverses in the form of a sluggish uniformly moving sheet or layer, lining large portions of the interior of the cell; I may mention hairs from the Elder (*Sambucus niger*) as an instance of this.

In all cases where the sap-motion is seen in the hairs of a plant, the leaf-cell displays analogous peculiarities, provided the cuticle is not too opaque, or strongly marked to obstruct vision. The cells are best obtained, by tearing off a layer of the cuticle from the stalk or midrib of the leaf, and must then be examined as speedily as possible, for the specimen loses its vitality much sooner than the hairs. There is scarcely a portion of a leaf-cuticle possessing the requisite transparency, taken from any plant wherein I have not discovered indications of circulation; even where there is no direct motion of particles to be seen, on account of their minuteness, the existence of circulation may still be known, from the following fact:—The *active corpuscles*, which are the primary cause of all the circulatory movements, are remarkable for their high refractive power, both on their completion, and in different stages of formation, and when arranged in a moving train, they appear as bright lines across the cell.*

Many specimens of leaf-cuticle, in which at first no movements whatever can be discovered, exhibit these lines, which

* As these observations were intended to be exclusively confined to the sap-circulation, I have been desirous of recording them in the simplest manner possible, and have therefore avoided technical expressions; what I have termed "the investment of active corpuscles," has been known as "protoplasm," or "cell-mucus." It may be doubted whether these terms are strictly applicable, or truly represent that which in reality consists of a multitude of particles, possessing individual activity and differing in size, and probably in chemical constitution, according to local position and the variety of plant-substance and tissue with which they are ultimately destined to combine, such as cellulose, and the *loose* contents of the cell, as chlorophyll- and starch-granules, the latter being most evidently formed by the successive deposit of *external* layers upon a central nucleus.

I may also remark, that it was formerly supposed, and some even now retain the same opinion, that the "circulation," "rotation," "gyration," or "cyclosis," in the vegetable cell, both in its early development, or growing stages, was in some way connected with a central nucleus, also kept in rotation, and termed the "cytoblast." I consider this supposition to be entirely fabulous, for whenever I have occasionally observed such a nucleus, it has either been formed by an accidental conglomeration of some of the cell contents, or by morbid conditions.

on being carefully watched, are seen to alter their relative positions, a condition evidently depending upon progressive motion. Most leaf-cells, of course, contain chlorophyll-granules; I have occasionally seen a few of these kept in a continual motion by the sap-currents, but never in any instance with the same degree of vigour and constancy, as in aquatic plants. In the cells of the common Plantain (*Plantago*) a few chlorophyll-granules are sometimes seen in motion. This plant furnishes an excellent object, as the cuticle from the stalk or midrib of the leaf shows circulation, both in the hairs and cells at the same time; the sap-motions round the latter are occasionally quite as plainly seen as in the *Anacharis*, but more frequently the current is one of extreme tenuity, and travels round the cell-wall with great velocity.

In the cells of the Horse Thistle (*Cnicus*) I have also seen the chlorophyll-granules carried along with considerable vigour by the sap-currents: this plant exhibits a remarkable variety in the phenomena of circulation. The glutinous corpuscles are connected together in the form of a line, or rope stretched across the cell, exhibiting a loose vibratory motion as if it were being shaken at one end, while particles and, occasionally, chlorophyll-granules, are carried forward in a manner resembling beads along a string.

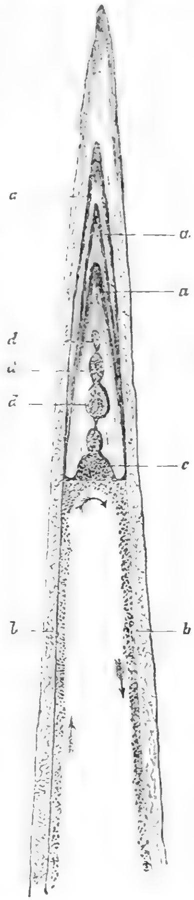
Having now noticed some of the distinguishing peculiarities of the circulation in a few of the plants that have come under my observation, I will offer some brief remarks on the vital principle of vegetable growth and motion. I had stated in my former paper that the cell-circulation, or what is termed "rotation," in the *Anacharis*, is entirely caused by the combined effort of a multitude of *active corpuscles;* the same fact equally applies to every other plant that I have examined; and subsequent experience has given me some further insight into the nature of these atoms; they evidently derive their origin and formation from the most fluid portion of the sap, with which every cell is filled, and which pervades all other portions of the plant tissues. In every stage of their growth they individually possess the motion peculiar to active molecules, but when in combination in their containing cell, this motion *is converted into one of direct progression* from some cause that I am not able to explain. I have tried by various means to effect a similar motion artificially in ducts and tubes, with both organic and inorganic active molecules, but without success; I therefore conclude, that the progressive movement is not due to any mechanical conversion of one force into another, but arises from some unknown property, connected with the vitality of the plant. I have witnessed the effect in

numberless instances in both the cells and hairs of plants. An isolated active corpuscle is seen detached, quickly performing its vibrations with constant activity, until its progress becomes arrested by one of the various ramified currents which traverse the hair; at which instant the vibratory movements totally cease, and the particle visibly assists the *direct-forward* motion of the current by its vital energy.

I observed with regard to the *Anacharis*, that after having been kept in a cold, dark place for one or two days, usually not a symptom of circulation could be discovered, the corpuscles having collected together in heaps, with the component particles in a state of torpidity, and on being again exposed to the stimulus of *light* and heat, they recommenced their active motions. This effect is still more remarkable in some non-aquatic plants; and a practised eye may at once detect, by the state of the cell-contents, whether the plant is in a state of repose or hybernation, as the corpuscles will in this case be seen collected together in several gelatinous-looking clots, their dormant vitality being again called into existence, by the same method as described for the *Anacharis*. Light is also quite as necessary a stimulus as heat; for in a recent experiment on this plant I interposed four thicknesses of blue glass between the achromatic condenser, and luminous source, (bright skylight,) thus entirely intercepting the heating rays, and yet, in spite of this intervening obstacle, speedily succeeded in exciting the movements of circulation.

The microscope discovers that in every portion of the plant each duct, cell, or vesicle, that is filled with sap, also contains active corpuscles, apparently differing in dimensions and substance according to locality. As regards the office that these bodies fulfil, it may be inferred that either they are the *vehicles* that convey nourishment to different portions of the cell-tissues, or that they themselves are deposited, to form the various structures of the plant. I will give an illustration of the latter effect. The annexed woodcut represents one of the hairs or spines taken from the stalk of the *Anchusa paniculata* (*Boraginaceæ*), an ornamental flowering plant of rapid growth. The growth of the spine is performed by the addition of successive layers to the interior, as shown at *a*, *a*, which eventually fill up the apex and render it solid: the method by which this action takes place is as follows:—A dense current of corpuscles are seen to travel along one wall of the spine, constantly returning by the opposite side, represented at *b b*. At *c*, where the deposition occurs, there is a considerable accumulation, and at the boundary, where they are converted into the substance of the spine, a number are

seen to be adherent. Some are but recently deposited, while the underlying ones are in various regular stages of transition, gradually losing their form and outline, and finally all traces of individuality become lost; and by a species of induration the particles become united and identified, with the solid body of the spine.



In very many specimens of this object that I have submitted to examination, the deposit has been so rapid, that there was not sufficient time for the complete condensation of the component corpuscles. In these instances a number of them have been caught and loosely enclosed in one or more cavities, as shown at *d d*, and, with the exception of being perfectly motionless, the contained corpuscles are the exact counterpart of those circulating in the spine. The walls of the containing cavities do not possess a definite outline, because they are lined with corpuscles in all their transition stages.

I have now brought forward the chief substance of my notes on this subject; they were made without previous study, and with an intention to avoid all hypothesis, and to confine myself to as clear a description as I could give, of any facts that the microscope might reveal.

There is yet very much to be learned respecting the sap-circulation of plants, particularly in their different organs; but the inquiry is attended with much difficulty, from the necessity of our being compelled to examine detached and lacerated specimens. In many examples this is not of material consequence, as in some aquatic plants, for in these the cells retain their independent motions and individuality, long after their separation; but in non-aquatic plants the case is somewhat different, for the mutual dependence of neighbouring cells is so considerable, that in many instances, death is the immediate result of detaching them, and the movements immediately to be seen under the microscope, are probably only the lingering remnants of vitality, and do not perfectly represent the circulation in the uninjured plant.

Lest it should be imagined, that I advocate the long-exploded theory, that supposed all vitality to originate with active molecules, I will venture, in conclusion, to make a few brief remarks in relation to them. The existence of active molecules has been known in a very early age of the microscope, but the first definite information on the subject, was given in the paper of Dr. Robert Brown, published in the 'Edinburgh Journal of Science,' for July, 1828. These observations rather tended to favour the above theory than otherwise, from the circumstance of his connecting together, without due distinction, both inorganic and organic molecules, some of the latter being obtained from actual living plants. The difference between *vital* and inorganic molecules is immediately perceptible, when submitted to the action of proper tests. Active molecules may be obtained from very many different mineral and inorganic bodies, as sulphur, limestone-rock, ashes, and even burnt clay. Their motions have been successively attributed to the influence of mutual attraction, caloric, and electricity; I have tried several experiments upon them with these two agents, but without obtaining definite results; nor am I yet satisfied with any explanation that has hitherto been given of the cause of their activity. I merely mention this in order to show the very wide difference existing between these and the active molecules, or rather corpuscles, contained in the vegetable cell; to all appearance their movements are identical, but the motion of the latter may be entirely suspended, or awakened, by the range of temperature consequent upon ordinary atmospheric changes. Their vital activity is immediately destroyed by a small trace of hydrochloric or sulphuric acid. The motion is increased by the agency of a slightly-alkaline solution, particularly that of ammonia; but this stimulant added to excess becomes a poison, and destroys the principle of activity.*

On the other hand, active molecules obtained from a powdered brick-bat, for example, may be exposed to considerable differences of temperature, without their motions being affected by it; and provided there is no chemical decomposition, they exhibit the same degree of energy, whether the solution be either acid or alkaline.

* A fact curiously in accord with what has been observed by Kölliker, with respect to the action of the same re-agents upon the spermatic filaments of animals.—Vide 'Quarterly Journal of Microscopical Science,' vol. iii., p. 293.—[Eds.]

Hartig *on the* Phytozoa *of* Antheridia. By F. Currey, Esq., M.A.

Was wird aus der Schwämfaden der Antheridien? Dr. Hartig has devoted a section of his essay on the development of the vegetable cell, now in course of publication in the 'Botanische Zeitung,' to a consideration of the above question, and the results he has arrived at are highly curious and interesting. Should further investigation lead to a confirmation of Dr. Hartig's views, the consequence will be that several genera of the Infusoria must be transferred to the vegetable kingdom. Dr. Cohn's lately-published observations, will have already prepared the minds of the friends of the Infusoria for such a result, and will cause the blow aimed by Dr. Hartig at the animal nature of some of Professor Ehrenberg's favourites to be less keenly felt. In the following pages we purpose giving the substance of Dr. Hartig's paper, which is of great interest to microscopical observers; the experiments are such as may be repeated without difficulty.

The author commences by observing that the phytozoa of the *Characeæ* are best suited for the observations in question, inasmuch as, when placed upon a slide in water, they are then in their natural element; but numerous observations made upon the Antheridia of *Chara*, *Nitella*, *Polytrichum*, and *Marchantia*, have led to the same results, and the last-named plant has the advantage of affording the easiest opportunity of procuring a large quantity of phytozoa free from the admixture of foreign bodies. To effect this, the disk in which the Antheridia are imbedded should be washed repeatedly with distilled water, its upper surface removed, and fine transverse sections taken from beneath. If these sections be placed upon a slide in a drop of distilled water, a vast number of phytozoary cells will escape from the segments of the Antheridia into the surrounding water.

A dozen, at least, of such sections should be prepared, and in order to prevent evaporation they must be placed upon clean oiled-silk, and covered with bell-glasses lined with moist blotting-paper. If these preparations be examined twice or three times a day, certain changes will be observed to take place in the phytozoa; and since these changes run through the whole mass of the phytozoa in each preparation, they must be considered as *normal*.

The above experiments constantly repeated have led uniformly to the following results.

The free phytozoa are very soon drawn to the edge of the drop of water (probably by the effect of evaporation), and

form there in the first instance a skin which covers the surface of the water. The form of the phytozoa is distinguishable in the granulated and serpentine disposition of the granules of this skin. Beneath this skin other phytozoa are seen in the state of motion peculiar to them. In the course of a few hours these latter phytozoa assume the form of Ehrenberg's genera *Spirillum* and *Vibrio* differing from that of the phytozoa only in the manifest articulation, and in the absence of cilia. At a later period the granulated skin extends from the margin over the whole surface of the drop of water, and the phytozoa underneath this skin are now seen, without any cessation of their motion, to assume forms similar to those of the *Spirilla* and *Vibriones.* The forms of *Vibrio rugula* and *V. prolifera* are most frequent.

After the first twelve hours all the phytozoa disappear, and there remain only the *Spirilla* and *Vibriones* in number proportionate to that of the original phytozoa.

The *Spirilla* and *Vibriones* exist for a very short time. After twenty-four hours most of them, after forty-eight hours all of them, have become disarticulated. The whole drop is now rendered milky and turbid by numberless globules similar to *Monas crepusculum* in a state of active motion.

The observer may be fully convinced that the forms of *Spirillum, Vibrio,* and *Monas*, do not originate from extraneous germs, and that they are not formed out of shapeless matter, but that they originate from the undecomposed substance of the phytozoa. The unusual rapidity of the transformations by which the process is kept, as it were, continually before the eye of the observer is a favourable circumstance in these observations.

It is an important circumstance that *Spirillum* does not originate from *Monas*, but always *Monas* from *Spirillum.*

After forty-eight hours, it frequently happens that amongst the moving monads which have hitherto been uniformly distributed through the water, small groups consisting of several hundreds of them are to be seen in which the primary active motion has ceased. Shortly afterwards a sharply-defined hyaline skin is formed round these groups, and, as it would seem, by the amalgamation or conjunction of the exterior molecules; by this means the young *Amœba* (Proteus) is formed. This transformation takes place pretty regularly towards the end of the third day.

The original size of the *Amœba* is 1-300''' in diameter. In the course of three or four days it grows to about the size of 1-100'''. This species differs from the *Amœbæ* hitherto described in the fact that the inner portion of the body which

bears the granules is much smaller than a certain hyaline covering, which covering is closely attached to the hinder part of such inner portion, but extends far away from the anterior part, and, in addition to this, the progressive motion in this species originates in an alternate enlargement of the longitudinal and transverse diameters, and is so slow as to amount at the utmost to no more than 1-40''' per minute. The form of the body resembles that of *Amœba princeps* (Ehrenberg). The vesicle in the hinder part of the body, which was first described by Ehrenberg as a mouth, and afterwards as an ovarium, is also present.

After four or five days the *Amœba* assumes a spherical shape and becomes motionless, the vesicular body expanding and contracting rapidly as before, in a manner similar to what takes places in many *Vorticellæ*. These spherical motionless *Amœbæ* are then for the most part united by a mucilage into groups of from ten to twenty. The mucilage appears to be produced by the decomposition of a cast-off external skin.

In about a fortnight after the commencement of the experiment a green point appears in the interior of the spherical colourless body of the *Amœba;* this point gradually increases in size until it fills up the entire hollow of the *Amœba*, and after becoming covered with a cuticle it escapes in the form of an elliptical bright-green cell, 1-300''' in diameter, resembling a *Protococcus.* It exhibits a round transparent cavity, devoid of chlorophyll, corresponding in size and position to the vesicular body of the *Amœba*, and resembling at its colourless apex the motile gonidia of *Cladophora.* A few days later the elliptic or roundish cell lengthens, a formation of transverse septa commences, and the uni-cellular alga becomes an articulated one.

All these transformations of phytozoa into *Spirilla*, *Vibriones*, *Monads*, *Amœbæ*, unicellular and articulated *Algæ*, may be observed, not only in the detached phytozoa, but in those which remain in the interior of the sections of the Antheridia. In those Antheridia of which the phytozoa are not fully ripe, the *Amœbæ* are seen to originate in the middle of the internal mass of phytozoary cells; some of them make their way out through the softened mass of cellular tissue, but others remain in the interior of the Antheridium until their development into an articulated Alga.

Contemporaneously with *Amœba*, and often earlier, there may be seen amidst the mass of Monads bodies very similar in form and motion to the genus *Bodo* (*socialis*), and which increase by transverse division; they have the front end

furnished with a long whip-shaped antenna or cilium similar to that of *Euglæna*. At their first appearance, their motion, their change of form, and their whole exterior, differ so little from the earliest states of *Amœba*, that at this period they cannot be distinguished. In these early stages they both resemble *Chlamidomonas destruens* of Ehrenberg.

The above forms uniformly make their appearance, and always in the succession above described. It is true that other forms, such as *Uvellæ*, and even *Leptomiteæ* and *Periconiæ*, are sometimes met with, the germs of which may have been imported by the atmosphere during the observation, but these organisms, *which always appear singly* and after the commencement of the observation, do not interfere with the above results, when we consider the immense number of the phytozoa and their uniform and contemporaneous transformations. If about a dozen preparations are made, and if they are carefully covered with a bell-glass after each observation, and if care be taken not to extend the observations for too long a time at once, at least half of the preparations will be free from all admixture of foreign organisms.

Dr. Hartig proceeds to remark upon certain transformations similar to the above, which occur in the motile gonidia of *Cladophora*, and he also notices certain *Amœbæ* which originate from the phytozoa of the *Characeæ*. Want of space prevents us from entering into the details of these latter observations, but it may be observed that in the *Amœbæ* of the *Characeæ* a remarkable circulation is to be seen similar to that which occurs in the cells of *Chara*. *Diatomaceæ* have been observed to force their way into the interior of these *Amœbæ*, and to be carried round with the current of the cell-contents. In conclusion, the author puts the following questions:—Does *Amœba* belong to the animal kingdom, or is it a stage of vegetable development? Assuming the latter, does this development ultimately lead to the production of the same plant from which it took its rise, or is the final stage of development dependent upon external circumstances? Are the phytozoa endowed with impregnative powers, and do they only become converted into *Spirilla* in the absence of those organisms upon which their impregnative powers are ordinarily exercised?

On a UNIVERSAL INDICATOR *for* MICROSCOPES. By J. W. BAILEY.

IN the 'Quarterly Journal of Microscopical Science,' vol. i, p. 34, an ingenious contrivance for registering the position of microscopic objects is described by Mr. Tyrrel; a modification of this, by Mr. Aymot, is given in a subsequent number (l. c., vol. i. p. 301); and a still better arrangement for the same purpose, suggested by Mr. Brodie and applied by Mr. Okeden to his microscope, is described at p. 166 of volume iii. of the same work. The last mentioned device can scarcely be improved upon for convenience; but there is one defect which is inherent to all these inventions, viz., that they are essentially selfish contrivances, of no use to any one but the owner of the particular instrument to which they may be attached.

The object of the instrument I propose is more comprehensive than that of the "Finders" above alluded to, being no less than to make a Universal Indicator, by means of which an observer can so register the position of any number of objects mounted upon slides, that when these are sent to a distant correspondent the latter may be able by means of the Indicator to find at will any of these objects, as easily as if he had the identical microscope and "Finder" by which they were at first recorded. If such a mode of recording the position of objects can be generally adopted that when the register is once made, the record and the objects shall then be entirely independent of the original instrument and observer, and applicable to any microscope, it will tend to promote science not only by facilitating the interchange of specimens among naturalists, but it will give to each observer's collection, when properly registered, a permanent scientific value and utility which it could have in no other manner.

The plan I have adopted is to make upon an engraved card what may be considered as a transferable stage, having guide-lines, by means of which the centre of the field of view of the microscope, and the position of a slide when any object upon it occupies this centre, may be given.

Plate V. shows the Indicator complete. The centre of the field of view corresponds to the intersection of the horizontal line C, D, with the vertical line E, F. On the right and left hand of this centre the vertical axes B and A′ are placed at distances of 4-5ths of an inch, and the axes A and B′ are similarly placed at the distances of 6-5ths of an inch from the centre.

The axes are then graduated as seen in the plate; the small divisions being each 1-50th of the standard inch.

The dotted lines G, H, I, give the outline of what will be referred to as the *centre-piece.*

Should it ever be desired to reproduce the Indicator by engraving or otherwise, the dimensions above given must be most accurately preserved. The dimensions here given were taken from the standard inch of the United States, belonging to the State of New York, and preserved in the office of the Superintendent of Weights and Measures in Albany. It is the same as the English inch.

The slides on which objects are mounted to be used with the Indicator must have *guide-lines* ruled on their *under side,* as shown in fig. 1 and 2. The horizontal line parallel to the lower edge, and passing through the middle of the slide, is not continued over the portion of the slide which is to be occupied by the objects and their glass cover. The distance of each of the vertical lines from the middle point of the slide is *one inch.* Great accuracy in the distance between these lines of the slide is not essential when they are to be used with the ordinary form of the Indicator as above given, but it is desirable when they are to be employed as hereafter described, with a modification of the Indicator applied to a moveable stage.

The slides should all be marked with an arrow placed upon their upper and right-hand corner, as shown in fig. 1 and 2, to point out the edge which must always be kept in front in using the slides upon the Indicator.

The Indicator is to be used as follows:—Cut out the centre-piece with a thin-bladed knife, following the outline G, H, I; then replace the piece cut out, and make a hinge for it along the line G, H, by pasting underneath it a piece of thin paper which will bear repeated folding, so as to connect it to the rest of the card.

The Indicator being now ready for use, it must be firmly secured to the stage of the microscope, in such a position that its centre as given by the intersection of the lines C, D, and E, F, when viewed as an opaque object, may be exactly in the centre of the field of view. If the stage is a moveable one, it must be kept stationary after the Indicator is properly centred.

The Indicator having been adjusted as above directed, the centre-piece is to be turned down, and the instrument is then ready for use, either to record new objects, or to find those previously recorded. The slide is to be put upon the Indicator, and guided either by the fingers or a moveable ruler, so that when any object which is to be registered occupies the

centre of the field of the microscope, the horizontal guide-line upon the slides shall pass through the same numbers on two vertical axes of the Indicator as remote from each other as possible. In some positions of the slide the axes A and B′ can be used for this purpose; in others A, and A′, or B, and B′ must be employed.

The horizontal line of the slide being arranged, as just directed, it will be found that at least one of the vertical guide-lines of the slide will intersect the horizontal graduation. By observing now the numbers at which the guide-lines respectively stand, the record can be made. Suppose, for example, that the horizontal guide-line ruled upon the slide intersects the verticals of the Indicator at 43, while the right hand vertical of the slide cuts the horizontal series of numbers of the Indicator at 75; the entry to be made for this object in the register would be written thus $\frac{43}{75}'$; and whenever that particular object is to be found either by the same Indicator or *any other copy of it*, if the slide is placed at these numbers, and the Indicator is properly centred, the object must be in the field of view. In the same manner any number of objects can be registered or found. If the slide happens to be so placed that both of its verticals intersect the graduated portions of the horizontal line C, D, the position of either one of them can be recorded at will.

If a guide-line upon the slide falls between two divisions of either scale, the fraction of the division may be estimated with sufficient accuracy by the eye or a hand-magnifier and entered in the register. Thus the recorded position $\frac{25\frac{1}{8}'}{34\frac{1}{4}'}$ would mean that the vertical lines of the Indicator were intersected at 1-8th of a division of the scale beyond 25, while the vertical guide-line of the slide passed 1-4th of a division beyond the number 34 of the horizontal scale, as nearly as could be estimated.

It is convenient to let the lower edge of the glass slide rest against a straight-edged guide-piece, which can be moved parallel to the horizontal line of the Indicator. By pushing the slide along this edge, all the objects on the same horizontal line can be found without changing the position of the guide-piece. By moving the guide-piece a little forwards or backwards another sweep across the slide may be made, and so on until every object of interest is found.

By following the directions above given it will be found that the recording or finding of objects by means of the Indicator is very easily performed, and scarcely requires the time which has been employed in describing the method. It is

believed that the explanation above given is sufficiently explicit to enable any one to use the Indicator; but some additional remarks will now be made upon the reasons for adopting the particular arrangement I have used, the modes of insuring accuracy in manipulation, and the modifications of which the Indicator is susceptible for individual convenience.

It was desired to make the instrument capable of universal application, so simple that it could be adapted to any stage; so light and yet so strong that it could be sent without injury by mail or otherwise to any distance; and, lastly, that the different copies should be perfect fac-similes of each other and reproducible at any time. All this is secured by having the Indicator engraved upon a steel plate and printed upon cards of uniform quality, and by taking the dimensions from the standard United States inch, preserved in the office of the Superintendent of Weights and Measures in Albany. In order to extend the use of the Indicator to all cases which are likely to occur, the graduation was arranged with reference to slides three inches long and one inch wide, while it will answer equally well for smaller ones. When these slides are not covered with paper, and guide-lines can be ruled as above directed upon the glass itself, the graduations necessary for their use would only extend upon the verticals $\frac{1}{2}$ an inch above and below the horizontal line, and upon the horizontal line only $\frac{1}{2}$ an inch outwards from the points 40 and 70; but in order to provide for paper covered, or opaque slides whose uppermost and lateral edges may be used as guide-lines, the graduation has been extended considerably. It will be found on trial that slides of the standard size, whether paper covered or not, may be employed with the Indicator for the registration of all objects under a glass cover of a square inch in size, which is quite as large as is likely to be used. In using covering glasses of an inch square it will be found necessary to employ the horizontal numbers 0 to 50, and the verticals A, A′, for objects towards the right of the cover, and the other axes and numbers for objects towards the left. For a portion of the objects under the cover, either set of axes and numbers may be used at pleasure, provided that the verticals are chosen as far apart as possible.

Two verticals on the same side of the centre should never be used together, as a small error in observing the numbers would have more effect in displacing the object from the centre than if two axes at a greater distance had been employed. The reason for leaving a blank ungraduated space between 50 and 60 on the horizontal line was to allow a fac-simile of the Indicator to be engraved upon the stage of any

microscope, the blank space being left for the portion of the stage occupied by the aperture.

The guide-lines upon the glass may be ruled with a fine-pointed scratching diamond, and be rendered more visible by having graphite or black lead rubbed into them. Lines ruled in this manner will answer for all except very minute objects; but in consequence of the widening of the lines by the chipping up of the glass due to unequal expansions and contractions, the lines often become too wide and irregular for very accurate adjustments. In such cases admirable guide-lines may be etched upon the glass with the *vapour* of fluohydric acid, and can be made of any required degree of fineness. The *solution* of the acid should not be employed for the etching, as it gives lines which are too smooth and difficult to see, and which will not retain the black lead if rubbed into them.

The power of the objective employed in determining the position of an object for registration, should always be the highest which can be conveniently employed; while in searching for an object already recorded, a power lower than that employed in the registration may be used. The object then must be in the field of view, and would be at the centre but for slight errors in manipulation, or the want of perfect adjustment in the mountings of the object-glass. Care should be taken to bring each object accurately to the centre of the field of view, before recording it. It will then require an error equal to half the diameter of the field of view to throw it out of that field. For example, the field of view of my ½-inch objective, made by Spencer, includes two divisions of the Indicator, and hence an error of nearly one division might be made in placing a slide upon the Indicator by means of its recorded numbers, and yet the object would be found in the field.

It may happen that in transferring a slide from one Indicator to another that the object when brought into sight by means of its recorded co-ordinates will not appear well centred. If this be due to slight differences in determining the centres of the Indicator, and yet the record has been carefully made, it is easy to correct for the difference in the following manner. Move the Indicator *with* the slide placed at any recorded position until the object comes into the centre of the field of view, then secure the Indicator to the stage in this new position, and all other objects recorded by the same Indicator ought to be brought to the centre of the field of view by means of the numbers as registered.

The convenience of the Indicator for individual use may be

increased by several slight changes. One of these consists in removing the paper centre-piece, and replacing it either temporarily or permanently by a glass plate bearing lines at right angles to each other ruled very lightly with a diamond point, and so adjusted as to coincide with the prolongation of C D and E F through the centre. For all but the highest powers there is no objection to having these excessively minute lines permanently beneath the centre of the Indicator, as they do not perceptibly interfere with the light, and it is convenient to have them always in place. They can be ruled upon a piece of mica or thin glass cemented to the back of the Indicator, or the latter may itself be cemented to a piece of plate glass and the central guide-lines then carefully ruled. Even for the highest powers these lines can be used in recording the position of objects, which can then be found for study by using an Indicator of the ordinary form. By a proper arrangement, a moveable stage, with screws for vertical and horizontal motions, may be graduated so as to correspond to the Indicator, and yet preserve all the advantages of accurate adjustment which the screws afford. For this purpose it is necessary to observe that if the Indicator be placed upon the stage and accurately centred, with its guide-line, C D, parallel to the front edge of the stage, and a slide be then placed upon the Indicator, so that its horizontal guide-line shall coincide with C D, and the right-hand vertical guide-line stand at 70, (*i. e.* in the position which would be recorded as $\frac{50}{70}'$,) or its left-hand guide-line at $\frac{50}{40}'$; then a motion of the stage itself bearing with it the Indicator and slide, or an equal motion of the slide upon the Indicator and fixed stage, will bring the same point of the slide to the centre of the field of view.

Therefore, by attaching to the stage in any convenient manner graduations corresponding to those of the Indicator, and by having lines corresponding to $\frac{50}{70}'$ and $\frac{50}{40}'$ ruled upon the stage, it will only be necessary to place the slide directly on the stage at these numbers, the stage itself being set either at $\frac{50}{70}'$ or $\frac{50}{40}'$ of its graduations. By turning the milled heads of the screws which give the vertical and horizontal motions of the stage, the object can be brought into the field of view, and recorded or found again by means of the numbers attached to the stage; while the record may be used for any other Indicator as if made in the usual manner. If the distance between the guide-lines upon the slide agrees accurately with that between 40 and 70 of the Indicator, the slide, when placed upon the moveable stage at either $\frac{50}{40}'$ or $\frac{50}{70}'$, will need no displacement for the whole series of numbers; but if this distance do not agree, the slide must be put with its left-

hand vertical coinciding with the left-hand vertical of the stage for all numbers from 0 to 50 of the horizontal series; while from 60 to 110 of the same series the slide must be set so that its right-hand vertical coincides with the right-hand vertical of the stage; in each case the horizontal lines of the stage and slide being adjusted to coincide. By observing this rule the necessity of perfect accuracy in the position of the guide-lines upon the slides is done away with.

There are some objections, but not insuperable ones, to the moveable stage Indicator as above described. In the first place, the stage as usually made has its motion too limited to correspond to the whole range of the Indicator; and secondly, the guide-lines ruled upon the stage for one object-glass may not answer for other powers on account of slight inaccuracies of mounting.

The stages can doubtless be constructed to give as wide a range for motion as required, which will do away with the first-mentioned objection. The second may be removed by placing an Indicator upon the upper plate of the stage when the latter stands at $\frac{50}{70}'$, and adjusting it so that when well centred *for the power employed* the line C F shall be parallel to the front edge of the stage. The slide being then placed upon the Indicator, with its guide-lines at $\frac{50}{40}'$ or $\frac{50}{70}'$, the remaining motions may be made with the screws in the usual manner, and the numbers may be read off from the stage-scales instead of the Indicator.

The above-mentioned modifications are excellent for individual convenience; but for the general purposes of science, the comparable, transferable, reproducible Indicator, in its simplest form, must be preserved; and it is only in that form that it deserves the name, suggested by a friend, of the Universal Indicator.

As a proof of the utility and accuracy of the Indicator, and of its convenience as a means of scientific exchange, I may state that numerous mounted slides of minute recent and fossil diatoms have been exchanged through the Post Office by Judge A. S. Johnson of Albany, and myself, and that each has found by the ordinary as well as modified forms of the Indicator all the shells, however minute, fragmentary or previously unknown, which the other had recorded. Some of these objects were less than 1-1000th of an inch in diameter, and yet they were found without difficulty by means of the Indicator.

To determine whether different impressions of the Indicator when made on the same kind of paper were comparable, a set of objects was registered successively by seven different im-

pressions made on enamelled cards, some of which were arranged with the ordinary paper centre-piece, and others with the central guide-lines ruled upon glass. The numbers being recorded for the objects when well centred upon one of these Indicators, the slide was then transferred to each of the other Indicators, and each object being brought into the field by its recorded numbers, the position was carefully adjusted so that the object should be well centered, and a record for each copy of the Indicator was thus made. On comparing the different numbers it was found that the coincidence was almost perfect, the difference never exceeding one-fourth of one of the divisions of the Indicator, an amount which might be quadrupled before an object would be thrown out of the field of view of my ½-inch objective.

The Indicator having been put to so many and such severe tests, I feel no hesitation in recommending it as a means of scientific intercourse among observers, and as a means by which collections of microscopic objects may be registered, arranged, and catalogued; and an index to the whole so made that any particular specimen may be found at will either by the original observer or any one into whose hands the slides and accompanying register may at any time come.

The copy of the Indicator which accompanies this paper is not given for use with the microscope, as the kind of paper upon which it is printed is different from that used for the standard Indicator, and therefore in consequence of unequal shrinkage a slight deviation is produced. The Indicator for use with the microscope is printed upon enamelled cards, and the different impressions have been found to agree so closely with each other as well as with the original plate that no appreciable error is perceived.

I cannot close this paper without expressing my warm thanks to Judge A. S. Johnson, of the New York Court of Appeals, for his cordial sympathy and aid in testing the merits of the Indicator, and for some excellent suggestions as to its best form for general use. I should also express my obligations to the engraver, J. E. Gavit, Esq., of Albany, who has spared no pains in making the steel plate from which the Indicator is printed as accurate as possible.

TRANSLATIONS.

On the Impregnation *and* Germination *of* Algæ. By M. Pringsheim. (Abridged from the Reports of the Berlin Academy.)

The existence of sexuality in the vegetable kingdom, though at first surmised simply upon a presumed analogy in this respect between animals and plants, and long a disputed point in science, has for some time been admitted as an indisputable fact. In the *Phanerogamia* especially, the necessity of the conjunction of the pollen tube and the ovule for the production of the embryo can no longer be denied by any one. Observations and experiments whose results admit of no dispute, have established this fact, although opinions may vary as to the *essential nature* of the act of impregnation.

The sexual organs of the higher *Cryptogamia* also are known; but with respect to the mode in which the respective organs participate *materially* in the act of impregnation, and even as regards the *necessity* of their co-operation, we possess at present little more than vague surmises.

In the *Florideæ*, *Fucoideæ*, *Lichens*, and *Fungi*, older and more recent researches have, at most, merely indicated the existence of organs to which sexual functions may possibly be assigned.

The latest endeavours, lastly, to demonstrate the existence of *antheridia* in the fresh-water *Algæ*, with the exception of certain fortunate indications, to which I shall return, may be said to have wholly failed.

This condition, however, of our knowledge, with respect to the sexuality of plants, cannot be regarded as very encouraging. For, admitting that, in order to prove the existence of sexuality it is not sufficient to show the presence of different organs, to which sexual functions may by possibility belong, but also to demonstrate the co-operation of these organs in the formation of the seed or of the young plant; it is obvious that the sexuality of plants, even in that division of the vegetable kingdom in which the organs to which the sexual function has been assigned are already known, has not been demonstrated with that degree of certainty which admits of no doubts being entertained. The grounds upon which the existence of sexual relations in the *Cryptogamia*, has been assumed, properly reside only in the analogy between

the bodies contained in the *antheridia* and the spermatic filaments in animals; and again, in a few isolated observations on the sterility of female Mosses and *Rhizocarpeæ* in the absence of the male plants or organs; and lastly, in the occurrence of hybrid forms among Ferns. All these phenomena, allow the true nature of the *antheridia* to be assumed with great probability, but they are insufficient to afford a scientific proof of it.

What has been wanting for a clear and convincing proof is the demonstration of at least a single instance, in which the *entrance* of the vegetable *spermatozoids* into the female organ, and their influence thereupon may be seen with perfect distinctness and in a way readily at the command of any observer. This requirement, however, is not fulfilled by our observations with respect to the process in the sexual organs in either the higher or the lower *cryptogams.*

I do not deny the value of Thuret's researches, which show, in the way of experiment, the sexuality of the *Fucaceæ;* but in morphological processes, direct visual observation of the process is necessarily of greater value than experiments which always leave room for some degree of doubt. Besides this, Thuret has merely stated the results of his experiments, and has not communicated the precise conditions under which they were instituted. Experimental researches of this kind, may, it is true, show the necessary existence of two kinds of organs for the formation of the young plant, but they throw no light upon the *essential nature of the act of fertilization.*

I am equally disposed to recognize the value of Suminski's statements, who says that he has witnessed the entrance of the spermatozoids into the *archegonium* of Ferns, in *Pteris serrulata;* as well as the importance of Hofmeister's observation, who has noticed the same thing in *Aspidium filix mas.* But in both these instances the tissue surrounding the *archegonium* opposes such difficulties to precise observation, and the phenomenon is so little under the control of the inquirer, that the witnessing of this occurrence can only be regarded as a rare piece of good fortune in an individual observer. Such instances are, certainly, wholly unfitted to constitute the basis of a general scientific conviction; leaving altogether out of question, the circumstance that Suminski's observations have received much contradiction, and that, in any case, he has been deceived as to the part played by the spermatic filaments in the *archegonium.*

It must, therefore, be regarded as a particularly fortunate circumstance, that I have succeeded in witnessing the process in a plant, in which it was possible to observe the penetration

of the spermatozoids into the female organ, with the utmost distinctness and clearness, even into the minutest details of the proceeding; in a plant, in fact, so happily organized that the fertilizing organs may be directly observed without injury to it in its natural condition; and in which, lastly, the female organ, owing to its transparency, offers such a slight obstacle to observation that the motion of the spermatozoids, within it, may be closely watched for hours together, so long as it lasts. I have noticed the gradual completion of both sexual organs so far, as to be enabled to describe the conditions presented in them, which immediately precede the commencement of the act of impregnation. These circumstances place the phenomenon so much under the control of the observer, that he is able previously to determine the time of the commencement of the phenomenon, and in a condition readily to demonstrate the whole act of impregnation before others. Lastly, since I have made these observations in *Vaucheria sessilis*, one of the lowest of the fresh-water *Algæ*, it would appear that the process of impregnation is at present more precisely known in one of the lowest divisions of the vegetable kingdom, than it is in any of the other higher plants, or in any animal; nor does it, furthermore, scarcely admit of doubt, that *sex is a universal property of all organisms, manifesting a wonderful analogy in the most highly organized animals, as well as in the simplest cellular plants.*

1. The *Vaucheria*, besides the asexual multiplication by zoospores, also exhibits a true sexual propagation, effected by means of the two organs, known as the hornlets (Hörnchen) and spores. Even Vaucher, who first noticed these organs, entertained a suspicion with respect to the nature of the "hornlets," which he declared to be the anthers of the plant, stating that the fertilizing pollen, which, as he thought, filled the entire tube, was discharged through them. With his means of observation he could scarcely have penetrated more deeply into the nature of the process, and it is highly to his credit that he should have advanced so far towards an explanation of it.

This view of Vaucher's with respect to the true nature of the "hornlets," is far nearer the truth than are the assertions of later algologists of the occurrence of a *copulation* of the "hornlet," and the contiguous spore, an assertion which is at once contradicted by attentive consideration of the relative positions of the mouth of the spore and of the "hornlet" before and after impregnation. The notion arose from a supposed analogy between the phenomena of fructification in the *Vaucheriæ* and the formation of the spores in the *Spirogyræ*.

This opinion, however, as well as Karsten's recent unfortunate exposition of the processes said to take place in the "hornlets" and spore-fruit of *Vaucheria* will be found to be untenable from the following description of the act of fructification in that plant.

But the *true process of impregnation* in *Vaucheria* and the development of both kinds of sexual organs—the "hornlet" and the contiguous stunted organ, which is more correctly termed "spore-fruit," [*sporangium*] than "spore," takes place in the following manner. Both organs arise like papillary branches from the tube, and in close proximity; and it is usually the case that the *papilla* destined to become the "hornlet," is formed sooner than that in which the spore originates (Plate III. fig. 1). The two *papillæ* even from the first differ so widely in dimensions, that they can scarcely be confounded. The *papilla* which becomes the "hornlet," soon elongates into a short, cylindrical, slender branch, which, at first, rises perpendicularly from the tube, then curves downwards until it comes in contact with the tube, often forming a second or a third curve, and in this way always represents a more or less stunted branch which frequently exhibits several spiral turns. The *papilla* of the neighbouring "sporangium," usually begins to appear at the time when the "hornlet" is commencing its first turn; but the period at which it arises is very indeterminate, for it sometimes appears much earlier whilst the "hornlet" is still perfectly straight, sometimes much later after it has curved, so as to form two limbs of equal length.

The *papilla* destined to become the *sporangium*, gradually enlarges into a considerable sized, lateral out-growth of the tube, far exceeding the hornlet in width, whilst in length it is barely equal to the straight limb of the latter (fig. 2). This out-growth, which is at first symmetrical, ultimately throws out a beak-like prolongation on the side looking towards the hornlet,—the "rostrate appendage," (*rostrum*) of the *sporangium*, whence the latter acquires its peculiar form, resembling that of a half-developed vegetable ovule (fig. 3). Up to this period the hornlet as well as the *sporangium* are not shut off from the tube from which they spring by any septum; the cavity of the hornlet and that of the *sporangium* consequently remain uninterruptedly continuous with the parent tube, and are filled with similar contents. A great number of elongated chlorophyll granules lodged in an albuminous plasma—never, in this case, starch—and rounded, larger or smaller oil globules, constitute a dense, internal lining in the tube, the *sporangium*, and the hornlet. Between this granular, parietal investment

and the true thick cellulose membrane, is a very thin layer of colourless substance which I have elsewhere described as the "cutaneous layer" (Hautschicht) of the cell-contents.* The *sporangium* is also especially characterized by the circumstance that a considerable number of oil-drops accumulate in it and apparently occupy the whole of its proper cavity.

At this stage of development, a *septum* is suddenly formed at the base of the *sporangium*, which is henceforth an independent cell, completely separated from the parent tube (fig. 4). Even before the *sporangium* has become separated from the parent tube by the septum, there may be noticed in the rostrate elongation directed towards the "hornlet," the gradual accumulation of a colourless fine granular substance, of the same nature as that with which the wall of the parent tube and of the *sporangium* is lined on the inner surface, and which, as I have already stated, has been termed by me the cutaneous layer. This accumulation of the "cutaneous layer" in the fore part of the rostrate process is continued after the formation of the septum between the *sporangium* and tube, and in consequence of its continued increase the remaining contents of the *sporangium*, the oil-drops, chlorophyll, and plasma are by degrees pushed towards the back and base of the *sporangium* (fig. 4). Whilst these phenomena are being manifested in the *sporangium*, the "hornlet" also undergoes very remarkable changes. In its apex, which, so long as the hornlet continues to grow, presents the same conditions as the summits of the growing branches of *Vaucheria*, the contents, owing to the disappearance of the chlorophyll, have become almost completely colourless, except that occasionally a few chlorophyll granules remain; sometimes more sometimes less. Thus the point of the "hornlet," like that of the *sporangium*, appears at this time to be filled with a colourless substance, but which is *not* constituted by an accumulation of the "cutaneous layer" at this point, but manifestly arises from a molecular change associated with an alteration of form and colour in the contents previously existing at the apex. This difference in the mode of formation of the colourless substance, occupying the apices of the horn and of the *sporangium*, should be carefully borne in mind; it is very essentially connected with the different morphological destination of the two substances. So soon as the contents of the point of the "hornlet" have become colourless in the mode just described, they appear to be constituted of a very fine-grained granulose

* A notice of the Author's 'Researches on the Structure and Formation of the Vegetable Cell,' will appear in the next Number of the 'Quarterly Journal of Microscopical Science.'

mucous substance, of whose constitution, however, no clear insight can be obtained. Now, so soon as the transformation of the contents has taken place, the apex of the hornlet, so far as it is colourless, is suddenly parted from the lower, green portion by a septum, and is thus transformed into an independent cell, having no communication with the parent tube, and the basal part of the hornlet. In this case the septum is not formed as in the *sporangium*, at the base of the process, but in the middle. But the point at which the septum is formed, in the "hornlet," is not very determinate; the portion thus cut off from the rest being sometimes larger sometimes smaller.

After the formation of the *septum* in the "hornlet," the colourless mucus in its apex gradually assumes a more determinate form, and at this time a large number of minute, perfectly colourless, rod-like bodies may be readily perceived crowded together irregularly, and which being still here and there surrounded by the amorphous mucus are, as it were, imbedded in it. Close observation also will disclose an indistinct movement exhibited even thus early by some of the little rods, and from which their destination may be anticipated.

This perfecting of the "hornlet" coincides in time with that stage of development of the *sporangium*, at which the accumulation of the "cutaneous layer" in the anterior part of the rostrate process has attained to its greatest extent; and this condition of the *sporangium* and of the hornlet immediately precedes the act of impregnation.

This is effected in the following manner: the pressure within the *sporangium* upon its walls, and especially in the direction of the *rostrum*, becomes greater and greater in consequence of the continued increase of the "cutaneous layer" in the forepart of the *rostrum*, until ultimately the membrane is ruptured exactly at the point of the *rostrum*, and allows a portion of the "cutaneous layer" to escape (fig. 6). The detachment of the extruded portion is attended with all the appearances which accompany the slow separation of a mucous substance into two portions, and which in the present case show in the clearest manner the non-existence of any membrane around the escaped portion of contents. This portion then assumes the character of a drop of mucus, which remains lying near the opening of the *sporangium*, and without undergoing any organization perishes, after exhibiting the various phenomena due to the absorption of water and disintegration (figs. 7 and 8). The accumulation of the "cutaneous layer" in the interior of the *sporangium*, in the anterior part of the

rostrum, and the escape of a portion of it, are merely the mechanism by which the opening is produced in the *sporangium* destined for the admission of the spermatozoids. Immediately after the formation of the opening in the *sporangium*, and in remarkable coincidence with the escape of the " cutaneous layer" through the *rostrum*, the " hornlet" opens at the apex and pours out its contents (fig. 5). Innumerable, excessively minute, rod-like corpuscles, most of them already nearly isolated, though many at the moment of the opening of the " hornlet" still imbedded in the mucus, escape at once though the orifice. Those already isolated exhibit an extraordinarily rapid movement in all directions, and those imbedded in the mucus do not become detached till afterwards, when they follow the others with equal rapidity. The field of view is soon covered with mobile corpuscles. In great number (20, 30, or more) they enter the neighbouring orifice of the *sporangium*, which they fill almost entirely (fig. 9), penetrating through the portion of the cutaneous layer remaining in the *sporangium*, which, though obviously without any definite membranous boundary, owing to its viscous, mucous consistence, offers a solid resistance to their further penetration into the *sporangium*. The corpuscles continue thus to struggle forwards into the "cutaneous layer" for more than half an hour; bounding against its outer surface they retreat, again push forwards, again retreat, and so on in an uninterrupted succession of assaults and retreats—wonderful spectacle for the observer! After this commotion has lasted some time an abrupt boundary-line suddenly appears in the outer aspect of the " cutaneous layer" (fig. 10), the first indication of a tunic forming around the contents of the *sporangium*, which were before bare. From this moment the mobile corpuscles are separated from the " cutaneous layer" by a membrane which effectually prevents their further action upon the contents. They continue, it is true, to move, to and fro, and in the roseate process, and this motion often lasts for hours together, but at last they perish in the *rostrum* itself, their motion becoming gradually slower and slower and finally ceasing. Even after the lapse of several hours, and when the act of impregnation has long been performed, the quiescent, dead corpuscles may be seen in the *rostrum*, lying on the front of the spore in the interior of the *sporangium*, until at last they are completely dissolved and all vestige of them disappears. The portion of the " cutaneous layer," remaining in front of the green contents of the *sporangium*, constitutes a thick stratum of a colourless and transparent substance immediately within the orifice in the *sporangium*,

and consequently the penetration of the mobile corpuscles, the *spermatozoids of the Vaucheria*, into the opening, and their continued efforts, as it were, to force themselves into the "cutaneous layer," may be observed with the utmost distinctness and precision. In several instances also, after the spermatozoids had already been for some time within the *sporangium*, I have very distinctly noticed the sudden appearance of a larger, colourless corpuscle at the extreme border of, but yet *within*, the cutaneous layer (fig. 10), and of which previously not a vestige was perceptible. Its sudden appearance *after* the impregnation, its superficial position in the "cutaneous layer," its consistence and aspect, allow scarcely any doubt to be entertained that this corpuscle arises from one of the spermatozoids. I shall subsequently describe a nearly similar thing attending the act of impregnation in the *Fucaceæ*, and will here merely advert to the remarkable circumstance that the act of impregnation does not take place between a perfectly-formed cell and one or more spermatozoids; but that the action of the spermatozoids is exerted upon the, as yet, unorganized contents of the *sporangium*, which do not become a cell surrounded with a membrane until after the act of impregnation has taken place—the true embryonic cell of the plant.

With respect to the *structure of the spermatozoids of Vaucheria*, I shall here merely remark that when in the mobile condition they present the appearance of elongated slender rods about 1-180‴ in size; when killed by means of iodine, whilst in this state, I have never been able to perceive any further structure in them. Whilst those spermatozoids which have ultimately ceased to move after long-continued struggling, but without having entered the opening of the *sporangium*, appear, very distinctly, like minute clear vesicles, also about 1-180‴ in size, exhibit a distinct opaque, *not* brown point, and, as I have seen with the utmost clearness, two cilia of unequal length. Their movement is obviously more like that of the corpuscles of which the contents of the *antheridia* in *Fucus* are composed, than that of zoospores.

I have stated that the portion of the cutaneous layer left in the *sporangium* after its bursting, and after the entrance of the spermatozoids, together with the remaining contents of the *sporangium*, are surrounded with a membrane, and become a cell which completely fills the *sporangium*—the embryonic cell of the plant.

The *formation of this membrane* of the embryonic cell of *Vaucheria* is one of the most convincing instances in favour of my views respecting the origin of the cell-wall, in an im-

mediate transformation of the "cutaneous layer" (of the so-termed "primordial utricle"). The separation of a portion of the "cutaneous layer," as above described, renders it certain that, at the time when the *rostrum* of the *sporangium* is ruptured, the contents of the latter are not surrounded by any proper membrane: but it is also obvious that the cutaneous layer, which after the escape of a portion of it through the opening still surrounds the green contents of the *sporangium*, and is accumulated in a particularly thick stratum over that part of the contents which correspond with the opening, diminishes considerably in thickness when the formation of the membrane ensuing upon the impregnation takes place; and this diminution in thickness goes on in proportion as the membrane in question *increases* in thickness (figs. 10, 11, 12, 13). In this case the transformation of the cutaneous layer into the membrane may almost be witnessed. This membrane gradually increases to a considerable thickness; at a later period it appears to be formed of numerous thin laminæ, and it applies itself to all parts of the open tunic of the *sporangium* (fig. 14). After the completion of the coat of the true spore, scarcely a trace of the previously well-developed cutaneous layer remains; an excessively thin parietal lining constituted of it alone remaining. The green contents, which had been forced back by the accumulation of the cutaneous layer, in the mean while again spread themselves uniformly throughout the perfect spore, and form as in all cells a thick, internal parietal coating.

The true spore thus formed by the impregnation represents, consequently, a large cell occupying the whole of the *sporangium*, whose membrane, formed probably *in consequence* of and certainly *after* the impregnation, appears to be laminated. It is surrounded on all sides by the persistent tunic of the *sporangium*, which is open in front and prolonged into the rostrum.

In this condition the spore remains for some time longer, without being thrown off from the parent tube on which it was produced: but the colour of its contents, which was at first green, gradually becomes paler and paler; the spore is at last rendered quite colourless, and presents in its interior only one or more largish dark-brown bodies (fig. 14, 16). When it has lost all its colour it is detached from the parent tube, in consequence of the decay of the membrane of the *sporangium* enclosing it (fig. 17). After some time (in my experiments, after about three months) the spore, which is readily recognizable by the red-brown *nuclei* in its interior, suddenly resumes its green colour (fig. 18), and immediately

thereupon grows into a young *Vaucheria*, exactly resembling the parent plant (fig. 19, 20). Close observation shows that the innermost layer, elongating, breaks through the thick outer membrane, and becomes the young tube, exactly in the same way as I have described the process of development in the germinating spore of *Spirogyra.*

The observation of the *germination* of this spore, however, completes the proof that the cell produced in consequence of the action of the spermatozoids is the true propagative cell of *Vaucheria* arising from a sexual act.

(*To be continued.*)

On SPHÆROZOUM, Meyen. (THALASSICOLLA, Huxley.) NOCTILUCA, *and the* POLYCYSTINÆ. By Prof. MÜLLER. ('*Report of Berlin Academy,' April* 19, 1855.)

IN the 'Annals of Nat. Hist.,' 2 ser., vol. 8, p. 433, Mr. Huxley describes what he regarded as a new genus of zoophytes, under the name of *Thalassicolla.* This production, whether animal or vegetable, is found in transparent, colourless, gelatinous masses of very various forms and size; showing no evidence of contractility nor any power of locomotion.

Of such bodies Mr. Huxley notices two very distinct kinds—the one, consisting of oval or constricted, and many spherical masses, is distinguished to the naked eye by possessing numerous darker dots scattered about in its substance; whilst the other is always spherical, has no dots, but presents a very dark, blackish centre, the periphery being more or less clear.

For the former kind Mr. Huxley adopted the provisional name of *T. punctata*, and for the latter that of *T. nucleata*, but without prejudging the question as to the existence of specific distinctions.

These creatures, which are described as consisting fundamentally of a mass of cells united by jelly, "like an animal Palmella," are placed by Mr. Huxley with the Protozoa, and regarded by him as belonging to the same great division as the *Sponges*, *Foraminifera*, *Infusoriæ*, and *Gregarinida*,—unicellular animals. Of the two species, *T. punctata* and *T. nucleata*, the former appears to present several varieties, and the latter seems to approach very closely in its nature to *Noctiluca.*

In the Reports of the Berlin Academy for April 19, 1855, is a paper by Prof. Müller upon *Sphærozoum* and *Thalassi-*

colla. The former name was applied, in 1834, by Meyen to a form of agastric animal, which he describes as a spherical, muco-gelatinous mass, constituted internally of globules, which again consist of vesicles. This genus, although Meyen's description is not quite accurate, would clearly appear from his figure, according to Prof. Müller, to be identical with the *Thalassicolla* of Huxley.

Prof. Müller then proceeds to describe and discuss the structure and varieties of the different forms assembled by common characters under this generic group, and fully confirms in every particular the description given by Mr. Huxley. But he is disposed to subdivide the *Thalassicolla* of that observer into two sub-genera, and adds an account of other specific forms. One subdivision of the group, for which he would retain the term *Sphærozoum*, Meyen, on account of its priority, would include *Sphærozoum* (*Thalassicolla*) *fuscum*, Meyen, and *S.* (*T.*) *punctata*, Huxley, and a minute description of their structure is given.

A second form, noticed by Mr. Huxley as a variety of *T. punctata*, and characterized by its containing in the centre a prismatic crystal, or crystals, and having a fenestrated shell not unlike that of a *Polycystina*, Ehr., he erects into the type of a distinct genus or sub-genus with the name of *Collosphæra*, assigning to it the specific designation of *C. Huxleyi.*

In his description of the structure, which corresponds fully with that of Mr. Huxley, he lays particular stress upon the nature of the crystals contained in the large cells. These are sometimes present in small, sometimes in considerable number, and in one case he counted twenty-seven in a single cell. They are about 1-60''' in length, clear and colourless, and from their form, together with their insolubility, of a nature altogether unusual in organized bodies. They are rhombic prisms, belonging to the two-and-two-membered system, with four-sided summits and a greater or less truncation of the acute, long angle of the prism. Upon measurement of the angles, which from the size of the crystals was not very easily taken, it appeared that the crystalline form agreed in a very remarkable manner with that of the sulphates of strontian and of barytes. Their chemical properties, also, which are described, would indicate that they were composed of a difficultly soluble earthy sulphate, which, however, could not be that of lime. And although strontian and barytes have not been observed in sea-water, the presence of the latter earth therein may be surmised from the circumstance that *celestine* is met with in the fossiliferous marine deposits, in the muschelkalk, lias, cretaceous and tertiary formations.

The author then discusses the question of the relationship of the *Collosphæra* with Ehrenberg's *Polycystina,* with the shells of which that of the former exhibits a striking resemblance, and especially with that of *Cenosphæra Plutonis,* Ehr.

Mr. Huxley's second species, *T. nucleata,* he conceives, requires much consideration before its true place can be assigned. But for the present he regards it as advisable to separate *T. nucleata* with the *Physematia* of Meyen from the gelatinous bodies with silicious skeletons, and leave the question of their true nature open. With reference, however, to the points of analogy indicated by Huxley between his *T. nucleata* and *Noctiluca,* especially in the fact of the motion of the granules in the interior, Prof. Müller takes the opportunity of noticing certain luminous bodies having the appearance of an encysted *Noctiluca miliaris.* "These encysted bodies," he says, "constituted the principal luminous animalcules observed at Messina in the autumn of 1853." Free *Noctilucæ,* at that season were not seen there; and in 1849 the same kind of encysted bodies were very common at Nice. The cyst is a perfectly transparent, spherical capsule, with a light-bluish brilliancy at the edge, and appearing like the egg-membrane of some crustacea. Within this cyst is lodged a body in all respects resembling the *Noctiluca miliaris,* except that at this time no vibratile filament can be perceived. The Noctiluca-like creature fills the cyst more or less entirely, though occasionally it is much smaller. In this condition the animalcules are luminous without being agitated. When the cysts are examined under the microscope in a small quantity of sea-water, in such a way that during the observation the saline contents are notably increased in consequence of the evaporation, a moment speedily arrives when the Noctiluca-like body suddenly contracts itself within its case into a little nodule, that is to say, it contracts upon the yellowish, granular *nucleus* from which the filamentary strings of the interior proceed. I have noticed this vital phenomenon, not on one occasion only, but in many of the encysted animalcules."

"The size of the case is usually from 1-5 to 1-4‴. But many are far smaller, even down to 1-10‴. Occasionally, also, instead of a *Noctiluca,* cysts may be observed, containing a yellow *nucleus* 1-24‴ in diameter, and once I noticed a cyst 2-10‴ in size, containing, besides this rounded yellow *nucleus,* quite isolated, an extremely minute Noctiluca-like body. Of the free *Noctilucæ* taken near Heligoland in the autumn, the smallest were 1-20‴ and the larger 4-20‴—7-20‴ in diameter. The common variety of form, with a constriction

of the circumference, which is noticed in free *Noctilucæ*, and the radiating filamentary branching striæ beset with extremely minute granules in the interior, were also characteristic of the encysted bodies, which I should be the more indisposed to separate from the *Noctilucæ*, from their possessing the most remarkable luminous power. At present we want the key to these remarkable phenomena, as well as all knowledge of the development and course of life of the *Noctilucæ*.

After discussing the probable relations of *Thalassicolla* with the *Sponges* and *Polycystina*—but without coming to any positive conclusion on the subject, except, that in any case the two forms of *Thalassicolla* and *Collosphæra* must go together—Prof. Müller proceeds to describe a new genus, apparently closely allied to them, under the name of *Acanthometra*, Müller. It consists of solitary, pelagic, silicious organisms, with a gelatinous envelope to the body. They are motionless microscopic creatures, constructed of a radiating silicious framework, the long, usually polyhedral crystals of which are disposed symmetrically in all directions, and meet in the centre without forming any central cavity. The needles are disposed in several decussating planes, and meet in the centre with their conical truncated extremities. This construction of the centre out of the conical ends of rays is observed in an otherwise widely different structure insoluble in acid, which Professor Müller has described and figured, from the intestinal contents of the *Comatula mediterranea*, and which has been termed by Ehrenberg *Asterolampra pelagica*.

The *Acanthometræ* differ from the *Thalassicollæ* in the junction of their spicules in the middle, and in the circumstance that they are solitary, and, so far, are a distinct formation. Like the *Polycystinæ* they do not constitute masses, but are distinguished from them by the absence of a fenestrated shell, as well as by the construction of their silicious skeleton. *Actiniscus* and *Bacteriastrium* differ from *Acanthometra* in the circumstance that their rays lie in a single plane and are united to a common centre.

Of the *Polycystinæ*, Professor Müller remarks, that species of *Haliomma*, *Dictyospyris*, *Encyrtidium*, *Podocyrtis* are occasionally brought to the surface of the sea by currents and other movements of the water; at any rate it is certain, that, though very rarely, they may occasionally be taken in the drawing of a fine net, on larvæ of *Echinoderms*, fully-formed young *Echinoderms*, *Medusæ*, *Crustacea*, *Pteropoda*, larvæ of *Gasteropods*, *Conchifera*, *Annelids*, &c., and on Infusoria; and the living *Polycystinæ* taken by him have been thus picked up on pelagic objects. In the same way also an

abundance of organic bodies are procured, which have been detached from their proper seat by the action of the sea, such as living arborescent *Vorticellæ* of the genus *Carchesium*, and Polypes. But heavier minute bodies, as the shells of dead *Polythalamia* are occasionally brought up from the bottom of the sea. With respect to living *Polycystinæ*, he remarks that they are not enclosed in a connected jelly, but that he has seen excessively delicate transparent, distinct filaments, without branches, or joints protruded from the fenestrated shell. These filaments are soft but straight, and it appears as if each filament proceeded from one of the openings in the shell. They resembled the radiating filaments of the jelly in *Acanthometra,* and of certain infusoria, as *Actinophrys*, but they were motionless. Within, the shell was always more or less completely filled with a soft, dark-coloured, usually brown substance, which had previously been observed by Ehrenberg in *Haliomma.* In the *Encyrtidium* of Messina the substance occupies the interior of the upper part of the shell, or the vault, and is very regularly divided into four lobes, containing a few clear, round corpuscles. In *Dictyospyris*, when crushed, there are seen in the interior of the shells, cells with yellowish granular contents. In a form, probably belonging to *Haliomma* or allied to it, having six spicules disposed in two planes crossing each other at right angles, the slimy matter in the interior of the shell contained both cells with yellowish granular contents 1-240‴ in size, as well as colourless cells and violet-coloured molecular corpuscles.

On the DEVELOPMENT *of the* SPERMATOZOIDS *in* TORREA VITREA. By M. A. DE QUATREFAGES. (‘Ann. d. Sc. Nat.’ 4me Sér. Tom. ii., p. 152.)

IN a memoir on the organs of sense in the Annelids (Ann. d. Sc. Nat., 3e Série, t. xiii), I designated, under the name of *Torrea vitrea*, a worm remarkable for the complex nature and the development of the eyes, and the extreme transparency of the tissues. Owing to this favourable circumstance, as well as to the unusual size of the spermatogenous masses, I was enabled at once to observe in it phenomena, of which I have spoken in a note annexed to the report of Milne Edwards on the results of his travels in Sicily (Ann. d. Sc. Nat., 3e Série, t. iii.), and concerning which I shall now enter more into detail.

The spermatogenous masses floating in the fluid contained in the general cavity of this Annelid are irregularly ovoid,

and present themselves, as is usual, in different degrees of development. At first they are perfectly diaphanous, smooth, and manifestly homogeneous, without any trace of an enveloping membrane. The dimensions attained to by them in this condition reach to as much as 1-16th of a millimeter in length, and 1-23rd of a millimeter in breadth.

At this epoch they may be seen to exhibit two grooves, crossing each other at a right angle, and whose direction has not appeared to me to present any constant relation with the form of the mass itself. It is probable that this first form of division may in some sort be accidental, for I have only very rarely noticed it.

The number of grooves soon increases, and they become more marked and deeper, and the mass, after having presented a surface subdivided into large irregular lobes, assumes a mulberry-like aspect, and ultimately becomes completely granulous. During the time that these phenomena are being manifested, the mass continues to increase in volume, and in its ultimate condition it is sometimes 1-12th of a millimeter long by nearly 1-16th of a millimeter broad.

The masses when a little further advanced soon split up, and the tail of the spermatozoids is then apparent. The spermatozoids continue to adhere to each other for some time longer by their bodies, as well as to the granulations not yet transformed; ultimately they are gradually separated.

At the moment when the spermatozoids separate themselves from the minute masses, of which they constitute a part, their body is almost fusiform, and perhaps not more than 1-100th millim. long, and 1-300th millim. thick. But they grow during the time they remain in the midst of the fluid which bathes them, the body and the tail elongate; and besides this the former increases considerably in its transverse diameter. Among spermatozoids quite mature, some will have attained to a length of 1-60th millim., and breadth of 1-150th millim.

I have long since remarked the analogy presented between the progressive breaking up of the spermatogenous masses and that of the *vitellus*. Numerous observers, it is well known, have confirmed what I have written on this subject since 1845, but it is a point upon which I have found myself continually at discord with some who have been specially engaged in researches of this nature.

In Germany, more especially, almost every naturalist who has spoken of the development of the spermatozoids has applied, in this department of physiology, the cell-theory of Schwan. The spermatogenous masses, in their eyes, have

represented the *mother-cells*, whilst the divisions of this mass have been *secondary*, *tertiary*, &c., *cells*. Lastly, the spermatozoids themselves have simply been the last generation of cells, separating themselves almost in the manner of vegetable spores.

When I made my observations on the *Torrea*, I sought with the greatest care to discover whether there were any envelope around the masses destined to be resolved into spermatozoids, and notwithstanding their unusual size in this worm I have never been able to perceive the least trace of such a covering. Neither have I been able to distinguish the walls of cells during the division. Since that time I have, many times, instituted researches of the same kind, and invariably with the same result. The spermatogenous masses have always appeared to me to be composed of a perfectly homogeneous substance, and never to present any indication of a cell-nature.

If to these observations are joined the *positive facts* which I have pointed out in the *vitellus* of worms and of the mollusca, the *negative* results which I have just recorded acquire, as it seems to me, a real value. Thus the cell-theory had been applied, very happily as it seemed, to the segmentation or division of the *vitellus;* but this doctrine necessarily succumbed before the fact that the most marked lobes, those in which both the *nucleus* and the *cell* could not fail to have been the best characterized, spontaneously fuse into one another. If, then, theoretical conceptions are discarded in favour of observation, the views which I have just explained will I hope be adopted ; and it will be acknowledged that in this case at least the cell-theory should be abandoned.

On the Influence of DILUTE SULPHURIC ACID *on the* DEPOSIT LAYERS *of the* CELL-WALL *in its earliest condition.* By Dr. T. HARTIG. (Botan. Zeitung, March 30, 1855, p. 222.)

IN a previous paper in the same journal the author has shown that the continued multiplication of cells in the ligneous and alburnum layers, is effected by a twin pair of parent-cells belonging to each fibrous ray, the inner one of which throws off a series of sterile secondary cells towards the medulla, and the outer a similar series towards the bark.

Each of the parent-cells, which correspond in size, form, and structure, consists of a thin cell-wall and a double ptychode-sac ; the cell-wall itself consists of an internal and of an external cell-membrane, between which is deposited a

greater or less number of astathe layers, which swell up strongly in sulphuric acid. (Bot. Zeit. 1854, p. 51, Tab. 1, fig. 16-17, *a*, *b*).

The youngest of the secondary cells, both of the wood and of the alburnum, exhibit no difference; they correspond in size, form, and structure not only with each other, but also with the two parent-cells, with which they constitute the compound layer designated the 'cambium.' The first apparent distinction in the structure of the secondary cells destined for the ligneous substance, and of those belonging to the alburnum, is shown in the dotting—the dots in the former being always distinct, and in the latter always grouped in a cribriform fashion. (Bot. Zeit. 1854, Tab. 1, fig. 24).

In the part of the ray belonging to the ligneous substance it is the cell-fibres and lamellar-fibres, and in that belonging to the alburnum substance it is the telial-fibres which retain unaltered the cambial condition of their walls; no further thickening of the wall ever takes place in these cells. In the ligneous part of the ray it is the woody fibres, and in that part which belongs to the alburnum it is the true alburnum-fibres which exhibit a further thickening of the cell-wall, which is effected by the deposition of new layers on the inner side of the cambial-wall. These layers of the second and subsequent generations afterwards constitute by far the main part of the thickness of the wall, whilst the cambial-wall contracts to such an extent, that its original constitution of cell-membranes and deposit-layers, which in the course of its development was distinctly demonstrable, is no longer perceptible. In this condition I have myself, he says, several times confounded the cambial-wall with what, in other situations, I have correctly described as 'eustathe' (intercellular substance, but not in the sense in which Mohl understands that term), or as 'cell-glue.' Thus, for instance, in my Leben d. Pflanzenzelle, t. ii., fig. 27 *e*, it is not 'eustathe,' but the cambial-wall, contracted by sulphuric acid and no longer capable of expansion, that is represented.

In a former memoir "Upon the formation of the deposit layers," I have shown how these additional layers arise from the regeneration of the ptychode-sac.

The additional layers of the second and subsequent generations, both in the ligneous and in the alburnum fibres, in their youngest condition, assume a beautiful rose-red colour when brought into contact for some hours with dilute sulphuric acid. In the same section and under precisely similar influence of the acid the cambial-wall remains unchanged, both in the region of the ligneous and of the alburnum-fibres, as well

as in the *cambium* and in the telienchyma, where no part of the wall at any age is coloured by sulphuric acid, owing to the circumstance that the entire cell-wall in these situations is composed of the cambial substance. It may thence be justly concluded that an *original* chemical difference exists between the deposit-layers of the cambial wall and the additional layers of the second and subsequent generations; and that this difference is manifested at a later period in the resistance offered by this parietal layer to the expansive influence of acids and alkalies.

The period is but very brief, during which the additional layers of the second and subsequent generations are reddened by sulphuric acid. In a shoot of *Pinus austriaca* examined on the 7th June, in which the annual ring had begun to be formed in the early part of May, only the 16-18 outermost fibres of each ray were reddened, whilst the older, 18-20 fibres assumed a brown colour. This gives a period of 2 or 3 weeks as the time during which the reddening effect of sulphuric acid is manifested.

On the Cystolites *or* Calcareous Concretions *in the* Urticaceæ *and other* Plants. By H. A. Weddel, Aide-Naturaliste in the Jardin des Plants. (From the Annales d. Sc. Natur. Ser. IV., tom. ii., p. 267.)

About the year 1827, J. Meyen discovered in the leaves of *Ficus elastica*, and of several other species belonging to the same genus, certain pedunculate corpuscles, constituted, as he supposed, of gum or of some analogous substance; he ascertained that these corpuscles increased by the superposition of new layers, and that ultimately they became covered with notches and elevations composed of a calcareous, crystalline material, soluble with effervescence in acids (carbonate of lime).

Long after this discovery by Meyen, M. Payen undertook the study of the same bodies, whose existence he demonstrated in a great many other plants belonging to the family of the *Urticaceæ*, and he concluded from his researches that their constituent material, which was regarded by Meyen as being of a gummy nature, was in fact *cellulose*, and that it was disposed, not in concentric groups, but in true cells united into racemose masses, each of which was destined for the secretion of a certain quantity of carbonate of lime. This view, which was adopted by several botanists, has been combated by others. Thus Schleiden, who was among the first to oppose it, appears

to think that the corpuscles in question are analogous to the deposits which, in time, obstruct the cavity of certain hairs, in the *Boragineæ* for instance; and which, particularly in the common Fig, may be seen prolonged into the cavity of the bulb of the same kind of hairs. The cells in which the corpuscles arise would even, according to Schleiden, be urticating hairs, whose base only was developed. The only argument which it is necessary to oppose to this theory, is the fact that the bodies in question are often seen beneath the epidermis and even in the medulla itself. Moreover, the deposit contained in the hairs of the Fig are formed in quite a different way from the gummy, calcareous, pedunculate corpuscles of Meyen, and behave towards reagents in a very different manner.

More recently, again, Payen's theory has found an antagonist in H. Schacht, to whom we are indebted for a very extended memoir on the subject. I shall content myself here with remarking, that he adds absolutely nothing essential to what Meyen had already stated with respect to the anatomical constitution of these corpuscles. Schacht, moreover, adopts entirely Payen's opinion as regards their chemical constitution, and notices them besides as characterizing the tissue of another large family of plants—the *Acanthaceæ*—in which their presence would seem to have been first shown by M. Gottsche of Altona.

Lastly, I have myself for several years studied these singular corpuscles; and the result of my observations has also been completely in accord with that at which Meyen had arrived. Struck with the differences, which seemed to me to exist between these bodies developed in special cells, and all the other mineral secretions of plants, I gave them the name of cystolites (κύστις, λίθος). These concretions, moreover, play a more important part in the physiognomy of the plants in which they occur than might at first be supposed, and are capable of furnishing the most valuable diagnostic characters; it appeared a useful object, therefore, to describe them more clearly than had hitherto been done.

Their figure is most commonly spheroidal; but in many of the *Urticaceæ*, and in a great number of the *Acanthaceæ*, they assume an oblong or more or less linear form, attenuated towards the ends, sometimes in that of a bow, or more rarely of a horse-shoe shape. In the living plant they are visible only on dissection or by transmitted light; the leaves in which they are contained then exhibit when viewed with a magnifying glass, translucid lines or points, but from which it would scarcely be possible to draw any precise diagnostic characters.

But this ceases to be the case when the plant is dried. The cystolites in fact do not contract in consequence of the desiccation like the rest of the tissue of the leaf or stalk, but are in a certain sense protruded externally, and the delicate membranous tissue covering them is moulded so exactly upon them that it is difficult when viewing them in this condition, to believe, that they were previously concealed in the thickness of the organ. Many botanists, deceived, under these circumstances, by their form, which is often linear, their white colour, and especially by the remarkable relief in which they stand, have described them as adnate hairs, others as Malpighian hairs, or lastly as simple tubercles. Gaudichaud was the first to recognise their mineral nature, regarding them, however, as true raphides, an opinion since adopted by several others, but which cannot sustain serious examination. Nevertheless the cystolites thus rendered visible on the exterior by the desiccation, furnish specific and even generic characters of great value in so natural a family as that of the *Urticaceæ*. Among the genera belonging to this great group, in which these little bodies especially afford good characters, I would here particularly notice the genus *Pilea*, of which the species at present known amount to more than 100; and the genus *Elatostema*, which contains nearly 40. Another genus of *Urticaceæ*, *Myriocarpa*, may be recognised at once, and in the absence of the organs of fructification, by the radiated disposition of the cystolites around the base of the hairs which clothe the upper surface of the leaves. In all these plants the calcareous corpuscles are, usually, more or less fusiform or linear; whilst in the greater part of the stinging *Urticaceæ*, in the *Parietariæ*, and in the *Böhmeriæ*, they are nearly always spheroidal, presenting, in the dried plant, the aspect of projecting points, which often give to the leaf a certain asperity, which would be sought for in vain in the living plant.

In all cases when studying the development of the spheroidal cystolites, I have had no difficulty in perceiving the pedicle, although it is sometimes very slender. This tenuity, however, of the suspensory filament is still greater in the linear cystolites; so great, in fact, that Schacht declares that he has sought for it in vain. Nevertheless there is no doubt of its existence, at any rate in the first period of the development of the corpuscle, for if the cell be viewed from without to within, a minute point will always be observed on its exterior, evidently marking the insertion of the pedicle. It may happen, moreover, that the suspensory filament is eventually completely concealed by the new layers successively added to the body of the concretion, which then appears to be sessile upon

the wall of the cell in which it is produced. In this case it resembles, to a certain extent, a Malpighian hair developed in the interior of a cell.

The size of these cystolites is extremely variable; those of a linear or fusiform figure, nevertheless, commonly attain to much larger dimensions than the others. In several species of *Pilea*, I have observed some more than a millimetre in length; whilst, on the other hand, there are some of a spheroidal form whose diameter scarcely reaches 2 to 3 1-100ths of a millimetre.

I have often been able to demonstrate, and as it seems to me beyond the possibility of error, the concentrically laminated structure of the body of the cystolite; but in no case have I been able to perceive in the pedicle the successive layers figured by Meyen and Schacht; it has always appeared to me to be a perfectly homogeneous appendage of the wall of the cell, and to arise from a circumscribed and continuous thickening of it. It behaves therefore towards reagents exactly in the same way as the substance of the wall itself, except perhaps that iodine develops, more frequently, traces of azotized matters. This fact did not escape the notice of Payen; and it cannot be doubted that this matter has something to do with the rapid development of these bodies. Perhaps the pedicle, directed towards the centre of the cavity of the cell, may act there like a foreign body, around which the calcareous matter is deposited. However this may be, the concretion and its pedicle always remain organically quite distinct.

With respect to the physiological import of the cystolites, considered generally, it is a point not easily determined with precision; but if their situation, and the time at which they acquire their complete development (the fall of the leaf), and lastly, their chemical composition be considered, they would appear to be rather a sort of *excretion*, than a *secretion* useful in any of the functions of the plant. In this point of view, therefore, the cystolites may very properly be compared with other mineral matters met with in the cells of plants, and in particular to those which occur in the crystalline form. Link, it is true, has compared the latter to the calculi occurring in animals; but the analogy between certain of these *calculi* and the cystolites, appears to me much more remarkable.

NOTES AND CORRESPONDENCE.

The Circulation in Aqueous Plants.—In the 8th number of the Journal, published in July, 1854, there is an account of the circulation in the *Closterium lunula*, by the Hon. and Rev. Mr. Osborne, and Mr. Hogg. This circulation, according to Mr. Hogg, is "no new discovery," but to me, as a young microscopist, I must confess it was so, as until I applied the parabolic reflector of Mr. Wenham, with the assistance of direct sunlight, I have never suspected it to exist. By this means of illumination, however, it appears to me to be very distinct, although I have seen it to better advantage in *C. acerosum.*

Some time in April last I met with some good specimens of this plant, and with $\frac{1}{4}$-inch objective of Smith and Beck their No. 1 eye-piece, Mr. Wenham's reflector, and a prism instead of mirror, with the assistance of direct sunlight, I had repeatedly the gratification of beholding what Mr. Osborne appropriately calls a "godlike" sight of the most beautiful, undulating ciliary motion, magnificently illuminated with prismatic colourings. After a longer time than usual spent over one specimen, the water in the cage partially dried, and on the edge of the air-bubble being brought by this means in close proximity with the specimen, the usual effect of external ciliary motion was most distinctly visible to myself and a friend for some considerable time, although no cilia could be distinguished. The rapid and continuous passage of a stream of molecules in the direction of the extreme end showed beyond the possibility of any doubt that cilia were there.

A few days subsequently I met with a good sample of the *Chara*, and it struck me to examine the circulation by the same illumination I had so successfully employed with *Closterium.* Judge my delight when I found precisely the same appearances, the same rapid undulations, together with the same brilliant coruscations, that almost satisfied me *that herein consisted the phenomenon of circulation in aqueous plants.* I am not aware that this has before been noticed, or at any rate recorded, and hope some more practised observers will put it to the test; for whether I am correct in supposing the circulation in water-plants originates in ciliary movement or otherwise, they will be amply repaid for the trouble expended, in the glorious sight presented to them.—James Western, *Veterinary Surgeon, Madras Artillery.*

On the Starch Grain.—In the Botan. Zeitung for June 8, 1855, p. 407, is a short notice, by O. Maschke, on the starch grain. Adverting to a paper "On the Structure of the Starch Granule," by Mr. Grundy, which appeared in the 'Pharmaceutical Journal for April 1855,' the writer refers to his own researches on the subject, made in the years 1852 and 1853, and published in the 'Journal für praktische Chemie,' vol. 56, part 7-8, and vol. 61, part 1; and states that in these communications he endeavoured to show:—

1. That the starch-grains are enveloped with cellulose, and consequently that they represent vesicles or cells.
2. That the starch-grains examined by him were constituted of several cells, arranged one with the other in a pill-box fashion.
3. That the *amylon* exists between these cells in a soluble or insoluble state, in the latter condition presenting the form of extremely minute granules.
4. That the so-termed nuclear point of the starch-grain is a central cavity in the innermost vesicle, which is sometimes empty in consequence of desiccation, and sometimes filled with fluid.
5. That the "moss-starch" (moosstärke) is merely *amylon*, modified by the action of acids (modified starch).
6. The "staleness" of bread depends upon the circumstance that the soluble starch, which exists in new-baked bread, passes into the insoluble condition.
7. That what is termed "leiocom" is produced simply from the action of an acid; and that this acid is formed in consequence of the elevated temperature necessary for the demonstration of this substance."

As the author does not appear, when these observations were made, to have been in possession of a good compound microscope, he may perhaps, when so furnished, see reason to change his opinion in some respects as to the structure of the starch-grain.

Aperture of Object-glasses.—Professor Bailey having noticed in the last Journal my remarks bearing reference to the fact of his being able to discover the markings on the most difficult tests known, when mounted in balsam, I beg to state, that my observations were dictated by no other motive than the desire of establishing a correct fact, and that I was not prejudiced by any favourite theory.

Professor Bailey says, "It is appparent from the above that Mr. Wenham has convinced himself, both by reason and

experiment, that I *ought* not to have seen the markings on delicate test objects, when mounted in balsam." From this I infer that Professor Bailey had not seen a paragraph contained in my communication, in the 'Quarterly Journal of Microscopical Science' for January, 1855, page 162, or I feel assured that he would not have thought it necessary to make this form of reply, for I therein assert that subsequent experience had induced me to recall my remarks, and that I had lately succeeded in bringing out the striæ of some very difficult tests when in balsam. I will now corroborate this by saying that I am convinced that Professor Bailey is perfectly correct in his statement with respect to balsam tests, which must henceforth be recorded in the list of facts. Thus far we are quite agreed; but as Professor Bailey's allusions extend beyond this point, self-defence will be my apology for taking some notice of them. Referring to me, Professor Bailey says, "The error in his arguments will be sufficiently obvious to any one, who will trace the course of a divergent pencil of rays *out of* the balsam instead of *into* it, as in Mr. Wenham's experiments, and it will then be seen, that large angles of aperture are as useful for balsam-mounted specimens as for others." Surely Professor Bailey cannot have well considered this extraordinary, because extremely incorrect assertion, which is tantamount to saying, that a diverging pencil of rays from a luminous point, submerged in balsam, will in each case continue their course in the same right line, without suffering any refraction, *after* emerging from a plane surface of the medium. This is contrary to all reason, for in the trigonometry of optics where there are sufficient data connected with the position and direction of the rays, it comes to precisely the same thing whether they are traced *into* the refractive medium or *out of it*. But taking Professor Bailey on his own statement, I will explain what is the real effect in this case. Suppose a series of rays diverging from a balsam-mounted object; from the mean refraction of the balsam and glass cover (the indices being about 1·54 and 1·53) *total reflection* would take place from the upper surface of the latter at an angle of very nearly 41° from the perpendicular. This, therefore, at once limits the angle of rays collected by the object-glass to 82°, and as total reflection begins where refraction ceases, all rays beyond this point will be entirely reflected down again into the balsam, and lost by dispersion; and the extreme rays of the pencil of 82° that just exceed total reflection by passing through the glass, so far from continuing their course in a straight line, are brought down by refraction to the very level of the top surface of the cover

itself, so that if it were possible to use an objective of 180° of aperture, the effect of balsam-mounting would reduce it at once to 82°, and allowing for all possible variations of the refractive powers of the balsam and cover, I have no hesitation in affirming that any object mounted in the usual manner in this medium, has *never* been seen with an angle greater than 85°; but in all probability the extreme limit has been about 78°. This statement is not the result of mere hypothesis, but admits of ocular demonstration, by experiments that will prove it at least half-a-dozen different ways, and is so true in theory, that to endeavour to disprove it will be to take the difficult course, of attempting to undermine the ground upon which I have taken my stand, by denying the first laws of refraction upon which my assertion is based.

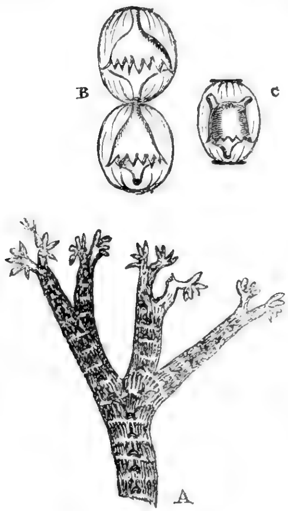
Professor Bailey has, no doubt, experienced the advantage of the utmost extent of aperture that can be obtained, in that particular department of investigation, in which he has so eminently distinguished himself; and I am willing to admit, that if the highest powers are to be used *only* for viewing thin and flat objects like the *Diatomaceæ*, the aperture may be as near to 180° as may be practically convenient for this especial purpose; but considering all the requirements, and perhaps more useful applications of the object-glass, I am still of opinion that beyond 150° there is no real advantage to be gained. I have expended much time, and taken special delight in the cultivation of the largest apertures, and possess an assortment ranging up to the greatest possible limit, and I can even now bring out striæ with 150° as readily as with anything beyond it, with the positive advantage of a greater distance between the front lens and object. Some of the phenomena described in my communication to the present Journal are extremely severe tests of all the good qualities of an object-glass, and yet I have had some, whose performance is unrivalled upon a difficult diatomaceous test, repeatedly break down and fail in their effective duty, when applied to the investigation of plant-circulation, from the fact of their possessing *too much* aperture.—F. H. Wenham.

On the Structure of the frond of Polysiphonia fastigiata.—The frond of *Polysiphonia fastigiata*, bearing antheridia, consists of a mass of transparent matter, in which are imbedded coloured, elongated cells or siphons. These are so arranged side by side in successive rows as to surround a central hollow passing through the whole extent of the frond. Each row of siphons with its hyaline matrix forms a kind of ring or section of a tube, and under pressure has a tendency to detach itself from

those next to it. These rings are articulated by some intervening dark matter laid transversely.

The tube thus formed is occupied by a series of clear vesicles of the same length as the siphons, which impress upon their outer surfaces a set of corresponding parallel depressions, and each vesicle contains an urn-shaped body of the same colour as the siphons. A row of spines is placed round the shoulder of this organ, and from either end a stem with a slightly-expanded termination passes out, by which all the vesicles and their contents are brought into connection. These urn-shaped bodies when immediately below a bifurcation of the frond are rather more squared than the rest, and give out a communicating process from each of the distal angles. The chain is in this manner continued upwards. The contents in the conditions in which I have seen them are mere granular matter. The same or corresponding structures have not been observed in other species of *Polysiphonia;* but in the frond of *P. fastigiata*, producing tetraspores, they are present.

No description or representation of them has yet been published, and their functional relations remain unknown.



Polysiphonia.

A. Terminal portion of a frond of *Polysiphonia fastigiata*, bearing antheridia.
B. Transparent cells containing urn-shaped bodies from interior of frond.
C. Urn-shaped body in cell from a part of the frond immediately below a bifurcation.

Further remarks on the Fly's Foot.—If Mr. Tyrrell's theory be correct, "That the Fly uses the hooks as levers to detach the foot," we should expect *à priori* that the Beetle did so: but the contrary is the fact. I placed one (not aquatic, or of the Curculio tribe) under the microscope, feet upwards, which was remarkably slow in its movements, and furnished with two circular pads, and one triangular, possessing trumpet-shaped hairs, and having the power of secreting fluid. When detaching the foot in walking, it raised the hooks first, and

kept them suspended for an appreciable length of time, *before* it raised the pads. I placed a blow-fly for examination, after having removed, under the influence of chloroform, the flap and two hooks of one foot, and about half the hooks of another: it could not attach the foot with one flap efficiently; but the one in which the hooks were so far shortened, that they extended only to the middle of the flaps, it used very well. Query, Would not the flap have been torn through, and half left on the glass, in this case, if the above theory were correct?

When the foot of the Midge (one of the *Tipulidæ*) is in action, it has the appearance of a horse's foot in miniature. I believe the Walrus, although it sometimes exceeds a ton in weight, has a similar apparatus to the Midge, by which it can support itself on the almost perpendicular sides of the immense icebergs it has to traverse.

The *Midge's* foot terminates in a single sucker, and has no hooks wherewith to detach itself.—J. HEPWORTH, *Croft's Bank.*

Microscopic Preparations.—From a notice in the Botanische. Zeitung for November 10, 1854, we perceive that Dr. J. Speerschneider, of Blankenburg, near Rudolstadt, in Thuringia, proposes, apparently with the co-operation of Professor V. Schlechtendal, to issue a collection of microscopical preparations, intended to exhibit the most important points with respect to the structure and development of plants. The entire collection will contain ten to twelve dozen preparations, and will be issued in five to six parts, each of which will cost only three Prussian thalers; and subscribers' names may be sent either to Dr. Speerschneider, as above, or to Professor Schlechtendal, at Halle.

PROCEEDINGS OF SOCIETIES.

Microscopical Society, May 23rd.

On a new form of Microscope. By Robert Warington, Esq.

In carrying on the observations in my small Aquarium, which have for some time past occupied my leisure hours, I was very anxious to bring the microscope to my aid in examining the minute organisms or delicate structures of the creatures I had the opportunity of noticing, and which had been maintained for a considerable period in a healthy condition; at the same time it was important to do this without disturbing them from the natural position they had taken up, or removing them from the water. It occurred to me that I could best effect this object by attaching the microscope to the edge of the table, on which the aquarium was placed, by means of a clamp, and that by shifting this along before the front of the tank I could range over all the objects situated at that part.

In searching among some old chemical apparatus for a clamp likely to be suited for this purpose, I happily found one that had been employed for carrying the plates or subjects in an electrotyping trough, and which appeared exactly adapted for the object I had in view, being fitted with two ears which projected from the back, and through each of which a circular hole was drilled for carrying a rod, one of them being supplied with a binding screw for the purpose of adjusting it to any desired length. As this clamp fitted well to the edges of the table, I had only to get an ordinary microscope body arranged, with a cradle-joint and circular rod attached to the back and end of the bar which usually carries the rack and pinion of the coarse adjustment, and the desired requirements were fulfilled. By this means several motions of the instrument were obtained: first, the power of elevation or depression, by means of the rod, in the front of the tank; second, the focussing for distance by the rack and pinion; third, angularity in the position of the body by the cradle-joint; fourth, the traversing motion along the margin of the table, and also a curvilinear motion of the instrument by the rotation of the circular rod in the back of the clamp.

This object having been completed to my satisfaction, it next became a question whether the instrument, with a few additions, could not be turned to more general utility as a travelling microscope, particularly for use at the sea-side. To effect this I procured a small flat block of wood having an upright piece fashioned at right angles across its upper surface, on the edge of which the clamp or saddle could be screwed, and the body of the instrument, being adjusted at right angles to the rod, thus brought to act over any vessel, as a saucer or plate, containing the object to be examined; the length of the rod being the limit of the distance over which it would range. This arrangement rendered the instrument doubly useful, and was found to realize all my anticipations.

The next step in its further development arose from the observation, that, when the wooden block was set upright, on the angle formed by the strut, or projecting ridge, and the bed, it inclined nearly at the angle, or diagonal direction, in which the microscope is usually employed, and that by shortening the block slightly on one side of the ridge the most comfortable position for observation could be readily secured; the clamp or saddle carrying the body being then attached over the upper extremity of the block. It therefore merely required a stage and mirror to render the instrument serviceable in this new form. This was effected, keeping the portability of the result always in mind, by inserting into the under surface of the block, at a proper distance, a dovetailed socket for the reception of an elongation, or tongue, of a moveable stage-plate, and below this a small ferrule was introduced for carrying the rod of the mirror.

It was also found that, by elongating the rod, and craning the body of the instrument over into a vertical position, it might be employed as a dissecting microscope; the only addition that was required being the insertion of another dovetailed socket into the block to carry the stage-plate in a horizontal position. With these various adaptations to the circumstances as they presented themselves, the little instrument assumed its perfect form.

As this original microscope was of inconvenient size and weight, and as there was no apparent reason why these objections could not be easily obviated, I determined to have a new one made, maintaining the same form and construction, but reducing the weight and dimensions wherever it was practicable; the result has been the small instrument which was submitted to the Members of the Society on Wednesday last, and which I shall now proceed to describe in detail.

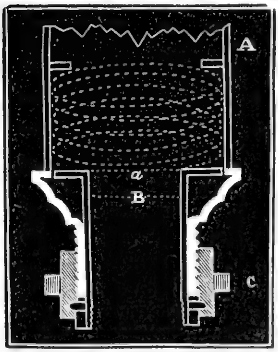
The block, or bed, is made of oak, or other heavy wood, of about half an inch in thickness, and is $7\frac{1}{4}$ inches long by 3 inches wide. Into this are countersunk the two brass dovetailed sockets, the diagonal one, or that which carries the stage plate in a diagonal position, and at right angles to the bed, at $3\frac{1}{2}$ inches from the upper edge, the horizontal one at 3 inches; the circular socket for receiving the rod of the mirror being inserted about $1\frac{1}{2}$ inch from the lower edge. At the back of the block are introduced two circular ferrules, $3\frac{3}{4}$ inches from the top, for the reception of two strong pins, which connect the strut, or upright piece, with the bed; this arrangement enables us to remove this from its position, and to pack the whole in a much smaller compass. In the side of the bed is also inserted another ferrule to receive the pin of a condensing lens for concentrating the light on the stage for opaque objects, or for the same purpose between the source of light and the mirror, it is placed $2\frac{1}{2}$ inches from the top.

The strut, or upright piece, is of the same width and thickness as the bed, and $3\frac{1}{2}$ inches in heighth, having two strong pins inserted for connection with the main piece.

The stage is a single stout plate of brass, of the same width as

the bed, and 3½ inches deep, bevelled at its sides, and having a short tongue, or elongation, at the lower edge, for insertion into either of the dovetailed sockets; it has a large central aperture, and is provided with a light cross-piece, fitting on the bevelled sides of the stage, and capable of moving easily up or down, for carrying the object-slides; at the right-hand corner of the stage there is also a small aperture, with a saw cut through its edge, for the reception of the pin of a pair of forceps. The small condenser may also be inserted below the stage into this aperture, so as to condense the rays from the source of light to the mirror, or between the mirror and the stage.

The clamp, or saddle, should be made as small and as light as is compatible with the thickness of the wooden bed, or stand, and the weight which the screws have to maintain firm and steady. The body is constructed of two tubes sliding the one within the other, so as to allow of its elongation to its proper length when in use. The outer one of these is embraced by a short tube two inches long, lined with cloth, and through which the body tube should have a steady and easy motion, as that forms the coarse adjustment. To the lower edge of this tubular support is soldered the cradle-joint with its attached rod; the latter being five inches in length. The fine adjustment, which I believe is new, is situated just above the object-glass; it is constructed on the principle of a common union-joint, the outer half of which works in a male screw at the extremity of the body-tube, and acts against a spring in order to maintain a constant bearing, thus:—A is the lower part of the body-tube, having a ring of metal as a stop in its interior, at 1, against which the spring, 3, bears, and having a screw on its exterior, at the lower aperture, for the half-union, C, to work in. B is the tube which receives the object-glass at its lower aperture, and has a ring of metal attached to its upper extremity, within the body-tube, at *a*, for the bearing of the lower coil of the spring, 3; it has also a slight projection on its exterior, near the object-glass, which is embraced by the curved extremity of the half-union, C.



The great object in this arrangement was to avoid the projection of a screw-head, which in packing away the instrument generally takes up so much space. By these modifications the whole instrument, together with a live-box, two object-glasses, the condensing lens, and the forceps, enclosed in a leather case, occupies a space of 8 inches long, by 3 wide and 3 deep; so that it can be easily carried in the coat-pocket. The cost is estimated at about £3 for the microscope complete, including the packing-case, without the powers; or with two French achromatics, at 15*s.* additional.

ZOOPHYTOLOGY.

In Johnston's 'History of British Zoophytes,' six genera of Vesiculariadan Polyzoa are described, but of which one, *Beania*, is more properly referrible to the cheilostomatous sub-order. To these have subsequently been added two or three others; as *Avenella*, by Sir J. Dalzell, *Mimosella* by the Rev. T. Hincks, and, more recently, a form described under the name *Nolella*, by Mr. Gosse. To this number we have now to add another generic form, new to the British Fauna, and a new species belonging apparently to the established genus *Farrella*, although the characters of that genus, as assigned to it by Van Beneden, will require some modification for its admission.

Order. Polyzoa infundibulata.

Sub-order III. Ctenostomata (Vesicularina).

Fam. 1. Vesiculariadæ.

§ 2. Polypides without a gizzard.

Gen. 1. Farrella, Ehrenberg.
Lagenella, Farre.
Laguncula, Van Beneden.

Char. Cells oblong or tubulous, scattered, arising from a creeping stotoniferous tube.

Farrella gigantea, Busk (n. sp.). Pl. V., figs. 1, 2.

Cells tubulous, sessile, not contracted at the base; tentacles numerous (18—20). Ectocyst flocculent, rendered opaque by imbedded earthy matter.

Hab. Tenby.

This very distinct form is characterized, in the first place, by the comparatively enormous length of the cells, which occasionally exceed 1-10th of an inch in length; and secondly, by the peculiar constitution of the wall or ectocyst. This is not horny and transparent, as in most of the other Vesicularidans, but appears to be of a soft, flocculent texture, in which is imbedded, as it were, an abundance of earthy matter, apparently derived from the mud in the water in which the creature lives, and consequently composed for the most part of argillaceous and silicious particles. A similar constitution of the ectocyst is observed in *Anguinella palmata*, and may therefore be expected to occur in others of the same family. This peculiarity of the ectocyst, and the extraordinary length of the cells, appear to constitute the chief distinctive characters between *Farrella gigantea* and what I take to be the *Avenella* (*Farrella*) *fusca* of Sir J. Dalzell. For specimens

of the latter species I am indebted to Mr. Wyville Thompson; and from one of these, fig. 3, Pl. VI., has been taken for the purpose of comparison; the two having been drawn under the same magnifying power. It should be remarked, however, that the specimen of the latter here figured was in the dry state, and consequently is somewhat distorted. But since these figures were printed I have met with a species of *Farrella*, parasitic upon *Flustra foliacea*, dredged in about 20 fathoms of water off Tenby, which appears to correspond with the *Avenella fusca*, and the examination of which in the living state has satisfied me beyond doubt, that that form and *Farrella gigantea* are quite distinct. In the 'Annals of Nat. Hist.,' 2nd Ser., vol. xvi., p. 35, Plate IV., fig. 29, Mr. Gosse describes and figures a Polyzoan belonging to the same family, under the name of *Nolella*, which would appear closely to approach in some respects, as he himself observes, the *Avenella* of Sir J. Dalzell; and from the semiopacity assigned to the ectocyst, it would also seem to correspond very closely with the form above adverted to, as found upon *Flustra foliacea*. The characters, however, assigned by Mr. Gosse to *Nolella* are apparently sufficient to remove all suspicion of this being the case. He says, that the "cells are erect, subcylindrical, springing singly, but closely from an undefined polymorphous incrusting mat; the tentacles (18) forming a bell." A copy of Mr. Gosse's figure of *N. stipata* is given in Plate V., fig. 4.

What is meant precisely by the expression "undefined, polymorphous incrusting mat," from which the cells spring, is not very clear. In all known Vesiculariadan Polyzoa, except *Anguinella*, the cells spring "singly" from a common tube; and if, as the use of the word "mat" might imply, the "polymorphous crust" is composed of tubes, the character is intelligible enough, and the species in accordance, so far, with its congeners; but if, as the expression might also be taken to convey, and as the figure certainly indicates, this crust is a continuous substance,—the condition is so peculiar as at once to raise the genus in which it is found to the rank of, at least, a distinct family group. It is more probable, however, that upon farther examination Mr. Gosse will find that the cells do really arise from a creeping adnate tube; in which case the genus will fall to the ground, and *Nolella stipata* have to be referred to *Farrella*, with the characters as here modified. If so, it would seem to correspond in all respects with *Avenella fusca*, Dalzell; or, at any rate, with the form occurring in *Flustra foliacea* above noticed, and which, if not the *Avenella*, is apparently as yet undescribed.

Between *Farrella* (*Laguncula*) *elongata*, V. B. (Rech. sur les Bryozoair.), p. 26, Pl. II. (*b*), of which an outline sketch (reduced from the original figure) is given in Plate VI., fig. 4, and *F. gigantea*, the difference is sufficiently obvious. This species has not yet, so far as I am aware, been observed upon the British coast, though it will in all probability be found to be a native.

The only situation in which *F. gigantea* has as yet been met with is in the neighbourhood of Tenby, and there chiefly in a cave in St. Catherine's Isle, which is only open at spring tides. In the autumn of 1854 the walls of this cave were in parts densely covered with this Polyzoan, growing in a close and thick pile, but inconspicuous among the numerous Sponges and minute vermidoms of similar colour and aspect, with which the surface of rock is covered. In the present year, however, the species is far less abundant in the same locality.

The species, as has been said, is remarkable for the gigantic size of the cells, which are often more than 1-10th of an inch in length. The polypide, however, is not beyond the average size in other Polyzoa. It has from 20 to 30 long slender, highly flexible tentacles.

Gen. 2. Anguinella, V. B. Rech. sur les Bryoz., p. 58.

Char. Cells tubulous, cylindrical, supported on a common stem (one springing from the base of another).

A. palmata, V. B. Pl. VI., figs. 1, 2.

The only species—

A. palmata, V. Bened. Rech. sur les Bryoz., p. 58. Pl. VII., figs. 18, 24.

Hab. Ostend, Van Beneden; Britain, Busk; River Deben, Suffolk; Tenby; Charleston, S. Carolina, U. S., Harvey.

The very peculiar conformation of the polyzoary in this species at once distinguishes it from all its congeners. It is farther distinguished from most of them by the constitution of the ectocyst, which contains imbedded in a soft, or rather flocculent substance, so large a quantity of argillaceous and silicious matter, that when exposed to the flame of a spirit lamp, it is converted into a kind of red earthenware, retaining its pristine form and dimensions, or nearly so.

It grows to a large size; many tufts or bunches reaching three or four inches in length. It is found on dead or living shells, and on stones, and closely resembles a small Fucus covered with mud. This peculiar colour and habit have probably been the reason that it has so long escaped notice on our coasts, where it will, in all probability, be found to

be pretty generally distributed, especially in muddy situations. Its wide distribution in the world is indicated by its occurrence at such a distant locality as South Carolina, the specimens from which in my possession were collected by Dr. Harvey.

In the river Deben, in Suffolk, which is more properly speaking an estuary than a river, scarcely a dead or living oyster-shell can be dredged up which is not covered by it. At Tenby it occurs, very sparingly, in the caves in St. Catherine's Isle.

ZOOPHYTOLOGY.

DESCRIPTION OF FIGURES.

Plate V.

Fig.

1.—*Farrella gigantea*, natural size.

2.—The same magnified.

3.—Mouth of cell, with the polypide partially extruded.

4.—*Nolella stipata*, Gosse.

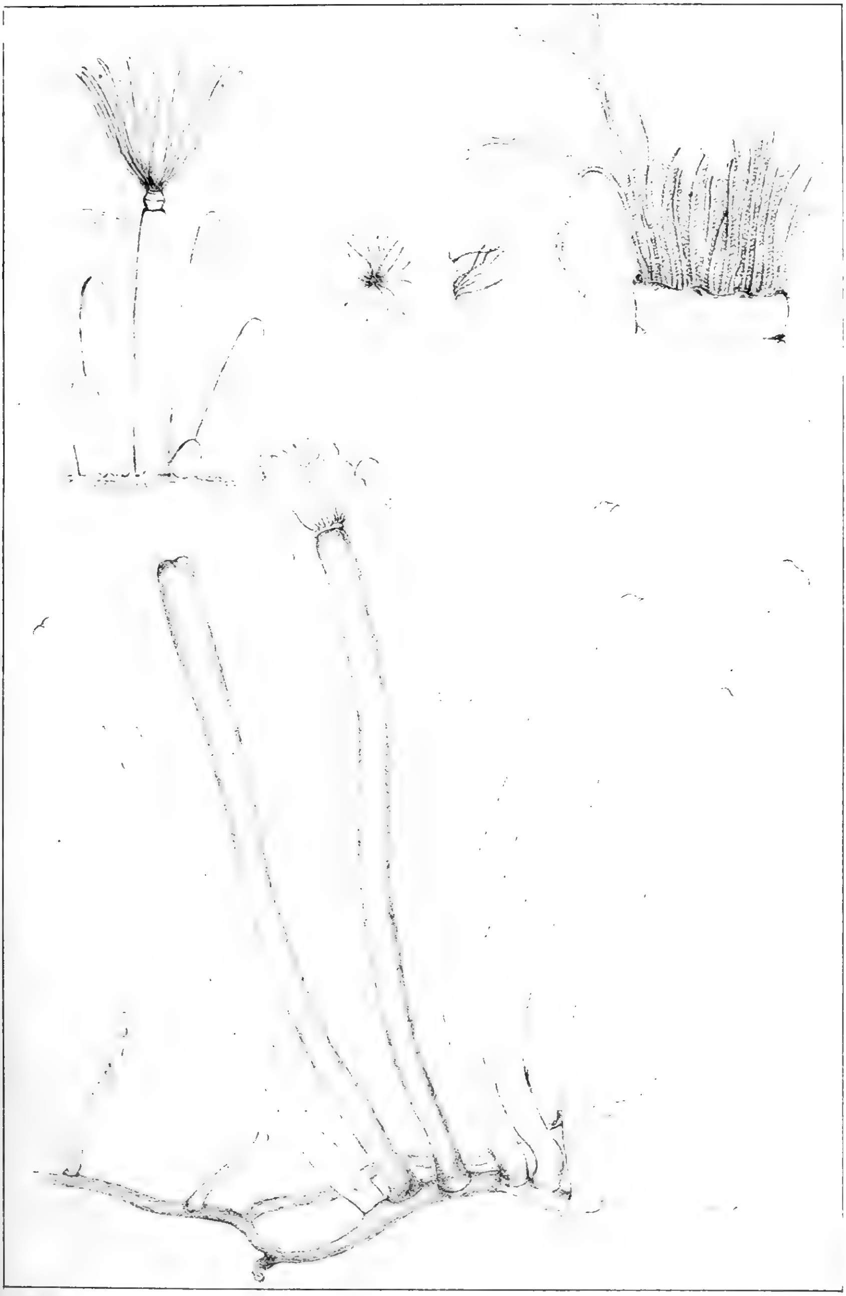
Plate VI.

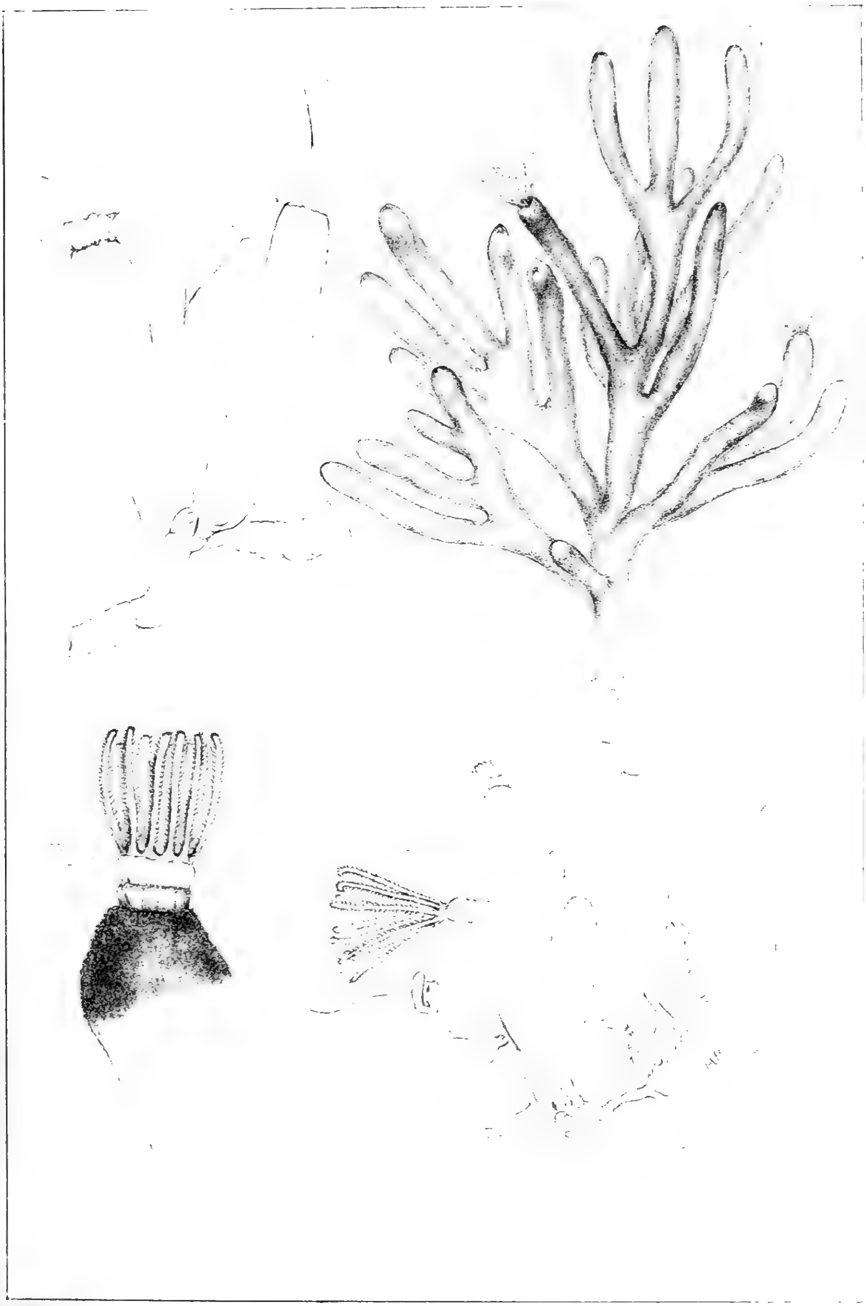
1.—*Anguinella palmata* magnified.

2.—Portion of cell, with polypide partially extruded.

3.—Outline sketch of *Avenella fusca*, which had been dried and compressed.

4.—Outline sketch of *Farrella* (*Laguncula*) *elongata*, Van Beneden.





DESCRIPTION OF PLATE I.

Illustrating Professor Gregory's paper on some new species of British Diatomaceæ.

N. B.—Most of the figures in this Plate have not been drawn to the scale now usually adopted, of 400 diameters, but to a scale considerably smaller, which, according to my estimation, does not much exceed 300 diameters. This remark applies particularly to the larger forms, such as figs. 4, 5, 6, 7, 11, 28, 38. The reader is requested to bear this in mind, when comparing these figures with those of the Synopsis of the Rev. Professor Smith. As for the smaller forms, they generally vary so much in size that the figures may be held to represent average individuals under a power of rather less than 400 diameters.

I. *Species new to Britain.*

Fig.

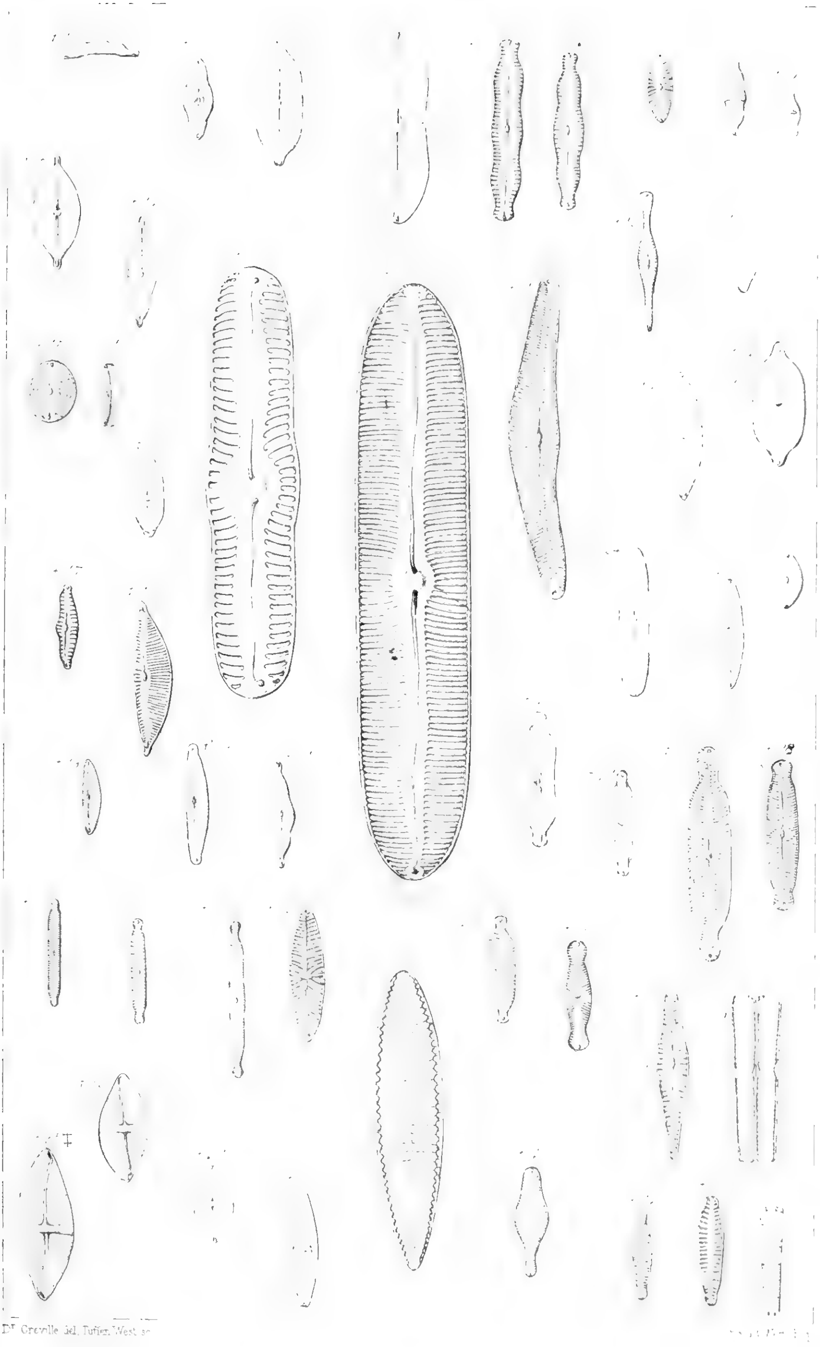
1.—Eunotia tridentula, Ehr.
2.—Navicula Trochus, Ehr.
3.— „ dubia, Kütz.
4.— „ Bacillum, Ehr. (qu. N. Americana, Ehr.?)
5.—Navicula (Pinnularia) nodosa, Kütz.
6.—Pinnularia megaloptera, Ehr. (P. pachyptera, Ehr.? P. lata, Sm., var.?)
7.—Pinnularia dactylus, Ehr.
8.— „ pygmæa, Ehr.
9.—Stauroneis Legumen, Kütz.
10.— „ ventricosa, Kütz.
11.—Cocconema cornutum, Ehr.
12.—Gomphonema subtile, Ehr.

II. *New Species, named by other writers, but not yet figured.*

13.—Navicula apiculata, Sm.
14.— „ rostrata, Sm.
15.—Navicula scutelloides, Sm.
16.—Mastogloia Grevillii, Sm.

III. *New Species, now first named.*

17.—Cymbella (?) sinuata, W. G.
18.— „ turgida, W. G.
19.— „ obtusa, W. G.
20.— „ Pisciculus, W. G.
21.— „ Arcus, W. G.
22.—Navicula cocconeiformis, W. G.
23.— „ lacustris, W. G.
23β.— „ „ var.
24.— „ bacillaris, W. G.
25.— „ lepida, W. G.
25β.— „ „ var.?
26.— „ incurva, W. G.
27.— „ longiceps, W. G.
28.—Pinnularia biceps, W. G.
28β.— „ „ var.
29.— „ linearis, W. G.
30.— „ subcapitata, W. G.
31.— „ gracillima, W. G.
32.— „ digitoradiata, W. G.
33.—Pinnularia Elginensis, W. G.
34.— „ globiceps, W. G.
35.—Stauroneis obliqua, W. G.
35‡.— „ „ with sigmoid median line.
36.—Stauroneis (?) ovalis, W. G.
37.— „ dubia, W. G.
38.—Surirella tenera, W. G. This form frequently occurs twice as large as the figure, but with the same proportions.
39.—Gomphonema insigne, W. G. Side view. *b.* Front view.
40.— „ ventricosum, W. G.
41.— „ æquale, W. G.
42.— „ Sarcophagus, W. G. *b.* Front view.



Dr Greville del. Tuffen West sc.

DESCRIPTION OF PLATE II.

Illustrating Mr. Busk's paper on *Sagitta bipunctata*.

Fig.

1.—*Sagitta bipunctata* magnified, dorsal view.
- *a*, *a*. Anterior pair of lateral fins.
- *b*, *b*. Posterior pair.
- *c*. Caudal fin.
- *d*. Spermatic cavities.
- *e*. Ejaculatory sac.

2.—Dorsal aspect of the head.

2*.—Inferior aspect of head and part of trunk, to show an apparent process, observed on one or two occasions, probably a parasite.

3.—Ventral aspect of the head.
- *a*. Oral denticles.
- *b*. Mouth.
- *c*. Hooks.

4.—Magnified view of posterior portion of trunk and part of the caudal portion of the body.
- *a*, *a*. Ovaries.
- *b*. Placental tract.
- *c*. Orifice of oviduct, which opens however above the fin and not below it, as here represented.
- *d*. Anal opening.
- *e*, *e*. Ejaculatory sacs.
- *f*, *f*. Spermatic sacs in the caudal portion of the body.

5.—A more highly-magnified view of one of the ejaculatory sacs, with spermatozoa swarming about the orifice (viewed on the side).
- *a*. The sac.

6.—A more highly-magnified view of one of the ovaries.
- *a*. Placental tract, enclosing—
- *b*. A cæcal canal;
- *c*. Ova, still attached to the placental tract;
- *d*. Orifice of oviduct.

7.—Cephalic ganglion and its branches (Huxley).
- *a*. The ganglion, composed of nerve cells in the central portion.
- *b*, *b*. Anterior pair of nerves, going to supply the buccal muscles.
- *c*, *c*. Posterior pair, or optic nerves.
- *d*, *d*. Middle pair, which pass downward on either side of the œsophagus, to join the ventral ganglion.
- *i*, *i*. Optic ganglia, which, according to Huxley, are contained in capsules.
- *k*, *k*. The eyes.
- *l*, *l*. A ganglioform enlargement of the optic nerve.

8.—The ventral ganglion.
- *d*, *d*. Anterior pair of nerves, going to the cephalic ganglion.
- *e*. A loose capsular investment of the ganglion.
- *f*, *f*. Posterior pair of nerves.
- *g*, *g*. Lateral nervules.
- *h*, *h*. Central tract of white nervous matter.

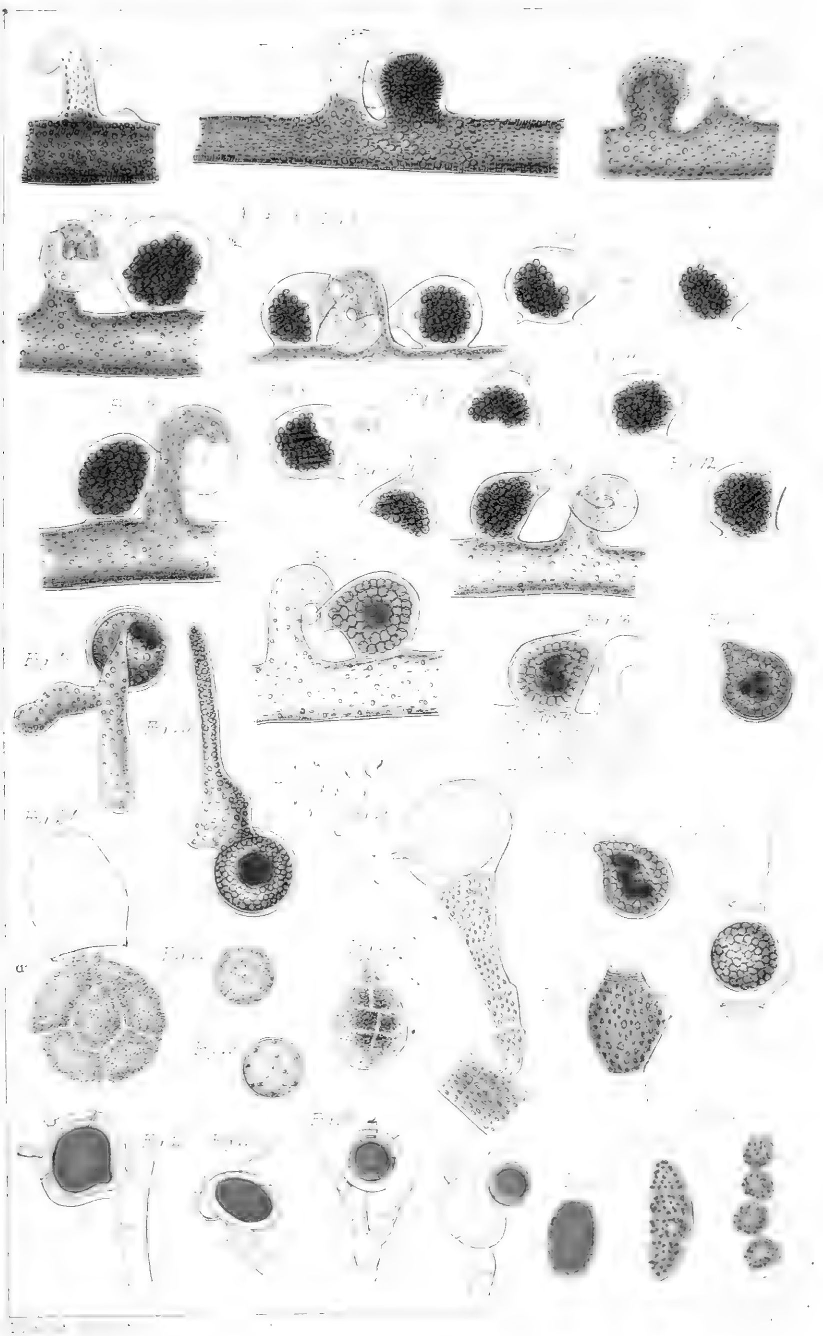
9.—Spermatic vesicles and cells.

10.—Diagrammatic view of the nervous system, taken from Krohn, with the omission of the supposed posterior cephalic loop.

11.—Mature spermatozoa.

12.—Spermatozoa in various stages of development.
- *a*. Early stage. *b*. Later stage.

C Busk del. Tuffen West sc.



JOURNAL OF MICROSCOPICAL SCIENCE.

EXPLANATION OF PLATE IV.

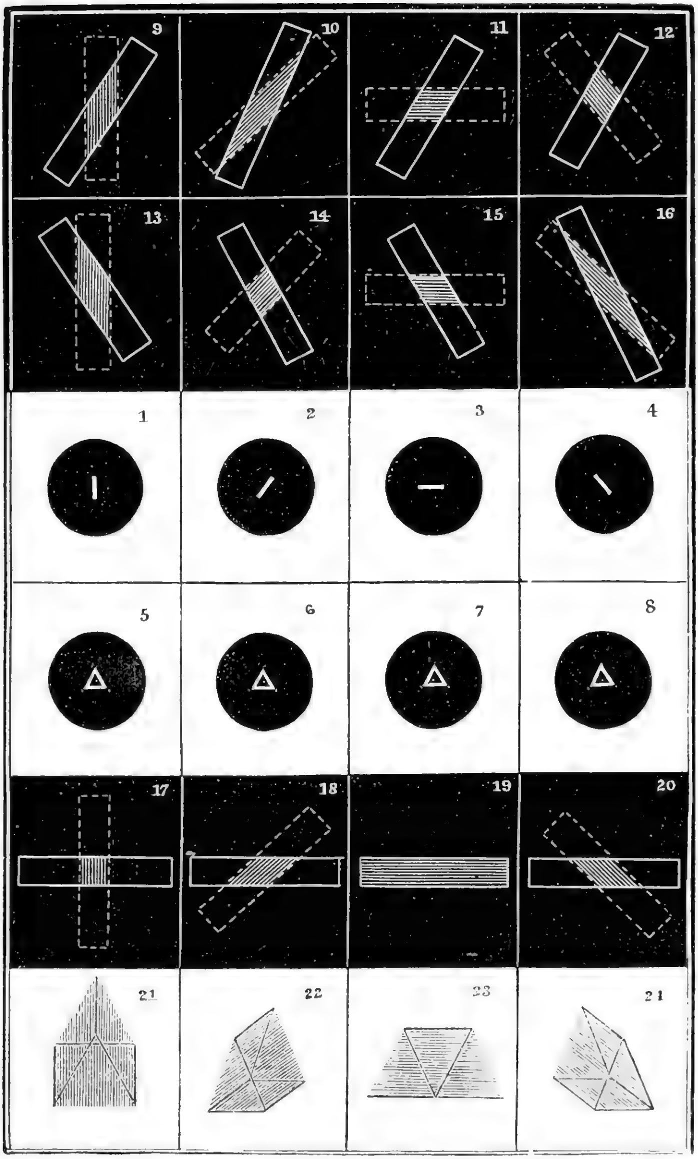
Illustrating Mr. Gorham's paper on the Magnifying Power of Short Spaces.

In the third horizontal column the single aperture which is held at the distal end of the instrument is shown in four of its phases of revolution.

In the fourth horizontal column, is delineated one of the objects (equilateral triangle) chosen for examination, and placed close in front of the eye in the circular end of the instrument.

The first, second, and fifth horizontal columns show in their uncombined state the planes which are formed by the mutual intersection of the two upper series. Thus the lines one and five contribute to the production of the planes nine, thirteen, and seventeen: the lines two and six to the planes ten, fourteen, and eighteen, and so on.

In the lowermost column is shown the coalescence of these planes into one entire form, the triangular prism, presenting itself in four different aspects, in accordance with the inclination of the lines 1, 2, 3, and 4, in the uppermost series.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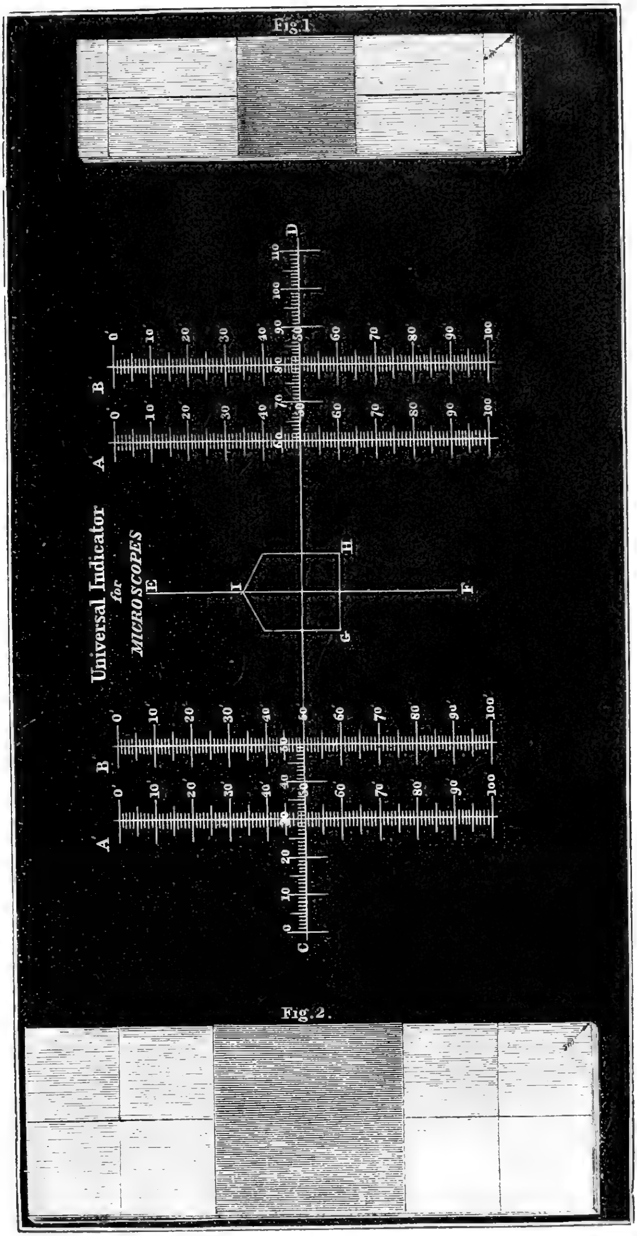


Fig. 1.
Universal Indicator
for
MICROSCOPES
A
B
C
D
E
F
G
H
I
Fig. 2.

ORIGINAL COMMUNICATIONS.

On CERTAIN CONDITIONS *of the* DENTAL TISSUES. By JOHN TOMES, F.R.S., Surgeon-Dentist to the Middlesex Hospital.

THE temporary teeth, when about to be replaced by the permanent set, lose their fangs by gradual absorption of their substance. The crown, when thus left, having but little hold upon the gum, soon falls out. The manner in which the absorption of the dental tissues is effected has been described in a paper published in the "Philosophical Transactions," in 1853. The subject is there mentioned in connection with the absorption of bone.

Having latterly had occasion to devote considerable attention to the phenomena attending the casting off of the deciduous teeth, several conditions relative to absorption have come under my notice, which, as applied to teeth, had, I think, hitherto escaped observation. It may, however, be here stated, that the more recent examinations have not led to any modification of the opinions upon the subject of absorption advanced in the paper alluded to, but have served rather to confirm the statement there made. Absorption may commence upon any part of the fangs of a tooth, and at several points at the same time. By the gradual extension of this process, both in depth and superficially, the root of the tooth is wasted, till, at last, nothing is left but the crown, and even this part is often so much hollowed out, that, excepting the enamel, but little of the tooth remains. The *cementum* is first attacked, then the *dentine* disappears, and the enamel at those points where the *dentine* has been entirely removed suffers from the same action. But whichever of the three tissues is attacked, we see the same characteristic surface as that shown by bone when undergoing a similar action, namely, a surface full of deep indentations, as though they had been made by a sharp piercing instrument, having a semicircular extremity. These minute holes or depressions proceed in various directions, several advancing from contrary points towards the same spot, not unfrequently isolate pieces of *dentine*. If a setion be taken through the substance of a tooth, so as to cut the wasting part at a right angle, we shall find the surface acted upon to have an irregular festooned outline, so characteristic, that when once seen it cannot fail to be again recognised.

It has been stated that, closely applied to the surface, a cellular mass will be found, and that this is but slightly adherent, the wasting and growing surfaces readily parting, unless the two are held together by the irregularities on the surface of the former. It will sometimes happen that the cellular mass penetrates into the *dentine* through a small opening, and there dilates, in which case its withdrawal becomes impossible. This condition is now and then found on sections prepared for the microscope, when we have an opportunity of examining the two tissues *in situ*. Indeed we shall find a few cells adherent to the surface of the *dentine* where less deep burrowing has occurred. The cells themselves do not present any peculiarity by which they could be readily recognised, if separated from the part undergoing removal. They are small granular cells, of a more or less spherical form. If a tooth which has lost its fang be carefully removed, we shall find remaining in its place a growing *papilla*, corresponding exactly in size and form to the surface from which it has been separated; and this separation may often be effected with so little injury to the absorbent organ, that no blood appears upon its surface after the operation, although the organ is highly vascular and readily torn.* The superficial extent of the papilla will be equal to that part of the tooth undergoing waste, but the extent, as regards depth, is slight, for, as the root of the tooth disappears, the socket is contracted by the deposition of bone, which forms at the base of the absorbent organ as rapidly as the cellular surface encroaches upon the tooth. The cases in which we find an exception to this condition are those in which the permanent has advanced close to the fangs of the temporary tooth, when the crypt containing the one communicates with the socket of the other, the rate of growth of the permanent having been greater than the absorption of the deciduous organ; but even in these cases we may generally observe some part in which the contraction of the socket is coincident with the absorption of the occupant fang. From the following quotation, it does not appear that Mr. Bell observed these conditions:—

"It has been already stated, that the permanent teeth during their formation are crowded together in the jaw, by being placed in a smaller arch than they would occupy if regularly placed side by side. As the latter, however, is their destined situation, we find that as soon as they are advanced to a certain point of their formation, and can no longer be contained within the *alveoli*, absorption takes place in the anterior parietes

* Laforgue and Bourdet recognised the presence of the absorbent organ, but supposed it exhaled a fluid capable of dissolving the roots of the temporary tooth.

of the cavities, by which means the teeth are allowed to come in some measure forward. In consequence of this absorption it often happens, that not only the socket of the corresponding temporary tooth, but that of the tooth on each side is also opened to the permanent one. Absorption now commences in the root of the temporary tooth, generally on that part nearest its successor, and thus goes on by degrees as the latter advances, until the root is completely removed, the crown at length falls off, leaving room for the permanent tooth to supply its place."

Mr. Bell, however, rejects the idea that mere pressure of the one tooth against the other has anything to do with the absorption of the first set; an opinion that he would probably have expressed even more strongly, had he observed the shallow but perfect sockets which are formed when the temporary teeth are shed before their successors are ready to appear. This, however, must be a very common condition, as I have in my own collection several specimens illustrating the point.

The fact was not overlooked, I think, by Hunter, although his description is not very clear. He states at page 99 in his 'Natural History of the Teeth:' "The new *alveoli* rise with the new teeth, and the old *alveoli* decay in proportion as the old teeth decay; and when the first set falls out, the succeeding teeth are so far from having destroyed by their pressure the parts against which they might be supposed to push, that they are still enclosed and covered by a complete bony socket. From this we see that the change is not produced by a mechanical pressure, but by a particular process in the animal economy."

But there is still a disposition on the part of many who are intrusted with the treatment of teeth, to attribute the absorption of the roots of the one tooth to pressure occasioned by the growth of its successor, and the development of the permanent may have something to do with the shedding of the other. But this does not offer a satisfactory explanation of all the circumstances attending the absorption of the fangs of teeth. In the first place we sometimes meet with cases in which the fangs of permanent teeth are as completely absorbed as those of the temporary organs. Then, again, the fangs of temporary teeth, which have no successors, are also absorbed. These circumstances, taken with the hitherto overlooked fact, that with the waste of the temporary tooth we have pretty generally a corresponding development of bone within the socket to be removed before the permanent tooth appears through the gum, render the pressure theory somewhat unsatisfactory. Another condition may be adduced, tending also against that opinion, namely, that temporary teeth occasionally maintain their place to the exclusion

of the permanent ones, which are then kept within the substance of the jaw, or appear in some unusual position.

The relations as regards time between the absorption and shedding of temporary teeth and the appearance of the succeeding permanent teeth, are by no means constant. In some cases the temporary teeth are thrown off two years before the corresponding permanent ones come through the gums. In others, again, the new will replace the old ones in as many weeks or even days.

Before the laws which regulate the absorption of the fangs of teeth can be fully recognised, a more perfect knowledge of the condition attending the process must be acquired. Recent examinations have enabled me to add the following additional facts bearing upon this subject to those already known. The process of absorption once commenced, it appears to have been assumed that the same action would be continued, with more or less rapidity, until the tooth falls out; or if not continual, is suspended only. Such, however, is not constantly the case. Not only is the action of absorption suspended, but one of development takes its place. We find the excavated surface of the *dentine cementum* and enamel covered with *cementum*, the latter following all the irregularities of the former tissues, and closely united to them. In cases where this development is going on, or being set up is maintained, the teeth afford considerable resistance when their removal is attempted. In those instances where the first teeth have remained, and tend to the displacement of the second set, this deposit of *cementum* will be found to exist in considerable quantity.

The development of bone upon the surface which had formerly been the seat of absorption, by no means indicates that the tooth will not again be subject to destructive action. On the contrary, specimens in my collection show that the bone deposited under the above circumstances may itself become the subject of absorption, that this process may be again suspended and development be renewed, that the absorption may again take the place of development; in fact, that wasting and reparation may alternate until by the preponderance of the former the tooth is shed. In sections of teeth showing this peculiar condition of development, we may find upon the growing bone numerous osteal cells, with here and there a lacunal cell. A bone *lacuna*, situated within a semicircular indentation in the *dentine*, gives the appearance of a lacunal cell, and a *lacuna* similarly situated in the *cementum* (a circumstance of common occurrence), has possibly been

supposed by Mr. J. Salter to be what has been described in the paper before referred to as a lacunal cell.*

The part of a tooth which has the greatest power of resisting absorption, is that in immediate contact with the pulp. We find examples in which a thin shell of *dentine* surrounds that organ, while that around it has been in great part taken away. This is, however, eventually removed, and the pulp itself changes its character, and becomes an absorbent organ, or makes way for that which is. In a fortunate selection we may find sections showing in one part *dentine* which has been but recently formed, with its modular outline and contiguous cells, capable of developing *dentine;* in another part absorption in active progress; and in a third the deposition of bone on the surface of the wasted *dentine.* In no instance, however, have I seen *dentine* deposited upon the surface of that which has been diminished by absorption.

It would appear that the dentinal pulp, although its function may be changed into that of absorption, or its place be taken by an absorbent organ, and this, again, changed to one for the development of bone, is incapable of resuming under any recognised circumstances its primary function of dentinal development. In other words, that a portion of *dentine* when removed by absorption, cannot be replaced;† while in bone, or *cementum*, the removal of a lost portion is of frequent occurrence. Sections taken from the teeth of adults seldom fail to exhibit points where the *cementum* has been removed and again added; and very commonly the absorption has at points extended a short distance into the *dentine*, and the lost parts made good with *cementum.* This condition may be observed in perfectly sound teeth; but in unsound ones, where the *cementum* exceeds the normal amount, the removal and renewal of tissue is still more marked. If the section be so made as to give a view of the surface of the pulp cavity, we shall probably find evidence of the pulp after the full develop-

* Transactions of the Pathological Society, vol. vi., p. 169.

† Since the manuscript was sent to the Editors of this Journal, I have seen a paper published in the last number of the Guy's Hospital Reports, by Mr. J. Salter, 'On Intrinsic Calcification of the Permanent Tooth-pulp.' Mr. Salter describes a section taken from a carious temporary molar, which was removed from the mouth of a person aged 18 years. The author states, that the "pulp was found converted into a mass of crusta petrosa and dentine confounded together." The drawing is beautifully executed, and shows, by the usual indications, that the pulp-cavity has been enlarged by absorption of its parietes. Judging from a view of the engraving only, it would appear that the tissue in contact with the wasted dentine is cementum only, while the newly-developed dentine is limited to the inner portion of the mass. If this view be correct, the specimen would have served for the illustration of the present paper.

ment of the tooth, having resumed its full formative powers, and produced new, or secondary *dentine*, the action having been excited either by the wearing away of the tooth or by the presence of caries. If the irritation be continued until it extends down the fang as far as its extremity, and signs of inflammation show themselves, the aperture of the fang will become enlarged by absorption, and after awhile the enlargement is continued to a considerable distance up the root of the tooth. The canal may be again contracted by the formation of *dentine*, or by the development of *cementum;* and I have seen one or two instances in which the greater part of the pulp cavity in permanent teeth has been lined with *cementum.* This condition of tissues is very common in teeth that have been long the subject of caries, but I believe it is not confined to carious teeth. I have several specimen of temporary teeth, in which the lower part of the root has suffered from absorption, and then has become the seat of deposition of *cementum,* leaving only a small canal in the centre. High up the root small patches of *dentine* have been removed, some of which only have been made good with *cementum,* while the contiguous parts have retained their usual condition.

It will be seen that the foregoing facts bear upon the opinions advanced by Mr. De Morgan and myself, in the paper on the structure and development of bone, before cited; that we have indications in teeth, as in bone, of alternations, of removal, and deposition of tissue. In the young subject, the development of bone tissue is in excess of absorption, allowing the bones to increase in size; that in middle life the two powers, under ordinary circumstances, balance each other, and the bones preserve their adult dimensions; while in old age the absorbent action appears to preponderate. Conditions pretty nearly parallel occur in the dental tissues after the temporary tooth has been fully formed; portions of *cementum* are removed, and with it, in some cases, a little *dentine;* the lost parts are replaced by *cementum*, and the tooth is again perfect. When the time approaches for shedding the teeth, the two actions alternate; but the absorption being in excess of the development, the tissues disappear, and the tooth is shed. After the formation of the permanent teeth we have occasional alternatives of the two actions; but they are balanced, and neither increase or diminution of size is observed. But as age comes on, it often happens that absorption is in excess, the fangs diminished in size, the teeth become loose, and fall out.

Observations on the Structure of the Enamel.

Without going fully into the structure and development of the enamel, and into the citations of the opinions published upon the subject, I wish to take this opportunity of recording certain observations which I have made upon that structure. The transverse striation of the enamel fibres has been frequently remarked, but the cause of these markings has not been determined. If sections from a number of teeth be examined, it will be found that the striæ are much more strongly pronounced in some specimens than in others, and most especially so in those in which parts of the tissue have a brown colour when seen by transmitted light.

The markings crossing the direction of the fibres are of two descriptions. The one arranged in contour lines, and situated at irregular distances from each other, uncertain in number and extent, and sometimes altogether absent. The other kind minute and regular, extending from fibre to fibre, and strongly resembling the transverse markings in voluntary muscle. In the present instance my remarks will be confined to the latter kind of markings.

In unhealthy subjects the permanent teeth, when they appear through the gums, are not unfrequently destitute of the brilliant white colour common to the finely-developed organs of a healthy child; on the contrary, they have an opaque yellow colour. If such teeth be selected for examination, we shall find that the sockets, when reduced sufficiently thin to be seen by transmitted light, present in the enamel a confused opaque appearance; but if a tolerably high power be used (such as the quarter or eighth object-glass) in conjunction with a strong light, the dark appearance will resolve itself into a series of lines; the one set marking the course of the fibres, the other taking the direction of the transverse *striæ*. The two sets of lines crossing each other at right angles leave interspaces approaching a square form. These interspaces are fitted with granular masses, having the appearance of cells. By treating the section carefully with dilute hydrochloric acid, these appearances become more distinct, and we then have series of parallel fibres composed of distinct sheaths, each containing a line of granular cells or meshes arranged in a single series, presenting a strong resemblance to the ultimate fibrilea of muscles. That such is the true structure of enamel is, I think, satisfactorily proved by specimens in my collections, some of which show the cells or granular masses; whilst others show the sheath, with the contents removed. Other specimens, again, show the enamel fibres in

the very young subject, deprived of their salts, detached from each other, and floating about in the fluid in which the section is preserved.

The figures illustrating these forms were drawn from specimens which retain the conditions figured. The appearances described do not admit of dispute; but the interpretation of their origin may perhaps be differently given by observers who do not agree upon the manner in which the enamel is developed. I do not propose to enter upon the question of development; but shall for the present leave the subject, after stating the varying conditions of enamel as it is found in human teeth.

In well-formed teeth, although the cell-like markings in the enamel are not by any means as distinct as in teeth in the condition I have described; yet having first examined the latter, but little difficulty will be experienced in recognising here and there faint indications of a similar structure, especially if the light be well managed. The more perfect the development of the tooth, the more transparent and free from markings will be the enamel, when seen as a microscopic object; and the less perfect the more distant will be the columns of granular cell-fibres.

Examples may readily be found in which the union between the enamel fibres is so defective that the tissue readily breaks down; a condition rendering it very difficult to grind it sufficiently thin for microscopic examination. When obtained, however, such specimens are very instructive, as they show distinctly the individual fibres and their contents, which in the most highly-developed tissue are so perfectly fused together, that the strongly-marked distinction of parts, which is so obvious in the one, is almost entirely lost in the other.

From what has been stated it will be seen that my view of the structure of enamel is as follows:—

The enamel fibres are composed of a sheath containing a series of cells or masses; that in perfectly-developed enamel, the cells or masses and sheaths are so blended that but slight distinction of parts remains, but that in less perfectly developed tissue the component parts remain visible.

(*To be continued.*)

On the FILAMENTOUS, LONG-HORNED DIATOMACEÆ, *with a Description of two new species.* By THOMAS BRIGHTWELL, F.L.S.

IN a gathering of Diatomaceæ, made by the late Mr. Wigham in July 1854, on the borders of the salt-water estuary, called Breydon, near Yarmouth, a singular filamentous, horned species was detected, allied to the genus *Chætoceros* of Ehrenberg.

An examination of this singular organism, (the first of the family which has occurred in this country), and a comparison of it with the allied forms described by Ehrenberg and Dr. Bailey, afford materials calculated to extend and correct our knowledge of this rather doubtful group of Diatomaceæ. Mr. Wigham's discovery will also, we trust, induce surviving labourers in the same field, to endeavour to add to our knowledge of existing species, as much must yet be brought to light before a satisfactory classification of this group can be effected.

Most of the described species have been found only in a fossil, or rather, if we may so term it, a deposit state; and in this state it is clearly difficult to form a correct idea of either species or genera, since deposits give no information as to the Diatoms being in threads or solitary frustules.

From this circumstance, and a disposition to describe every variety of form, and even many fragments of Diatoms, as species, both species and genera have been multiplied to a perplexing extent. It appears probable that there are few, if any, instances of truly *fossil* Diatoms, but that all the so-called fossil species are only deposits from still-existing and living species; and it is only when we have the living Diatom before us, that we can give any specific or generic characters that can be at all relied upon.*

The discovery of a new and living species of *Chætoceros*, and a careful examination of most of the species of this and several other allied genera, described by Ehrenberg as found in a fossil state, have satisfied us that most, if not all these, will, when found in a living state, turn out to belong to the singular filamentous and horned group, which may for the present, with some extension of its character (such as is hereafter attempted in this paper), be comprehended in the genus *Chætoceros*.

The typical species of Ehrenberg's genus appears to be *C.*

* In proof of this, Ehrenberg's genus *Biblarum* seems entirely composed of the *disjecta membra* of several genera, as *Tetracyclus*, *Odontidium*, and some others. *Tetracyclus emarginatus*, Wm. Smith, (*Biblarum emarginatum*, Ehr.,) has been found recently, in a living state, both in Ireland and Scotland.

didymus. This occurs not unfrequently in guano. The horns proceed immediately from apertures on each side of the frustules (an essential character of Ehrenberg's genus), and differ in this respect from our newly-discovered species, in which the horns proceed from, or rather are an elongation of the intermediate rings.

Two species from the Antarctic Sea are briefly described by Ehrenberg (*C. dichæta* and *C. tetrachæta*); each frustule is smooth, and the horns (of which the former species has two on each side, and the latter four) are very long and filiform. These species were, we believe, found in pancake-ice, and were brought home by Dr. J. D. Hooker.

Two species from Bermuda earth, marked as doubtful, are described by Dr. Bailey (*C. bacillaria* and *C. diploneiis*), and he has also recently described and figured a remarkable species, named by him *C. boreale*, found in the stomach of *Botriodactyla grandis.** The horns of this species are very long, and armed with numerous minute spines. Dr. Bailey describes and figures a small species also found in guano, named by him *C. incurvum*, which we have found plentiful in South American guano.

Of the allied genus *Goniothecium*, eight species are described by Ehrenberg, all found in the Richmond earth, North America. The two largest and most common are *G. Rogersii* and *G. odontella*, and we think it probable these will turn out, if discovered in a recent or living state, to be *Chætoceri*. Of the remaining six species, we are led to conclude, from the discovery of the Breydon species, that two of them belong to the genus *Chætoceros*, and are, when living, filamentous. They are *Goniothecium gastridium*, of which we have found many specimens with the horns perfect, and *G. crenatum*. A figure of a frustule of this species is given in the Microgeologie of Ehrenberg; and it can scarcely be distinguished from the frustules of the Breydon species. Similar frustules are of frequent occurrence in African and other guano, and in several fossil earths of marine formation, and we have detected recent specimens in a gathering lately sent us from Monterey Bay, North America. *Goniothecium hispidum* and *G. didymum* of Ehrenberg, scarcely appear to differ from some of the smaller frustules of the Breydon species. *G. navicula* and *G. barbatum* are marked by Ehrenberg as doubtful species of *Goniothecium*; but are clearly allied to *G. crenatum*, or our Breydon species.

Several other fossil genera of Ehrenberg contain species which will probably be found to belong to the long-horned filamentous Diatoms. *Xanthiopyxis cingulata* has precisely

* See Smithsonian Contributions to Knowledge, Feb. 1854, pp. 8, 9.

the cup-shaped and hispid character of our Breydon species, but is destitute of the neck. *Syndendrium diadema* and *Dicladia capreolus* are common species; they are found with the other *Chætoceri*, in various earths, and guano, and appear to be of the same family. They are chiefly distinguished by long styles, proceeding from the rounded end of the frustule, which styles are branched at the end, and are not unfrequently found with a portion of the membrane adhering to them, in which they seem to have been imbedded. *Omphalotheca hispida* has the appearance of an imperfect frustule, and *Mastogonia prætexta*, of a semi-frustule of *Goniothecium Rogersii*.

We venture to give a synopsis of the *Chætoceri*, adapted to our present imperfect state of knowledge of these singular organisms.

CHÆTOCEROS.

Filamentous; filaments elliptical, fragile, imperfectly siliceous. Frustules without striæ, united in pairs by the interlacing on each side, of horns proceeding from the frustules, or from a cingulum between the frustules. Horns often of great length, and sometimes spinous, or serrated.

§ *Horns, four on each side.*

1. *C. Tetracheta*, Ehrenb., Kutz., spec. Alg. 138.

§§ *Horns, two on each side, and proceeding from tubular apertures in the frustules.*

* *Horns filiform.*

2. *C. Dichæta*, Ehrenb., Kutz., spec. Alg. 138.
3. *C. Didymus*, Ehrenb., Kutz., spec. Alg. 138.
4. *C.? Bacillaria*, Bailey, Kutz., spec. Alg. 138.
5. *C.? Diploneiis*, Bailey, Kutz., spec. Alg. 138.
6. *C. Gastridium*, *Goniothecium Gastridium*, Ehrenb., Kutz., spec. Alg. 23. See Plate VII., figs. 3—8.

 N. B.—To Ehrenberg's description should be added, "Cornubus utrinque duobus." This species clearly belongs to the genus *Chætoceros*. Many examples have occurred with the horns perfect. See Plate vii., fig. .

7. *C. incurvum*, Bailey. Smithsonian Contributions, Feb. 1854, p. 9. Plate VII., figs. 9—11.

 We have found this species abundant in guano.

Mr. Tuffen West has detected in guano frustules of a species, belonging to this section, which is new to me, and may perhaps be **C.** *Bacillaria*, Bailey. For figures of these frustules see Plate VII., figs. 1, 2.

** *Horns spinous, or serrated.*

8. *C. boreale*, Bailey. Smithsonian Contributions, Feb. 1854, p. 8. Plate VII., figs. 12—15.
9. *C. Peruvianum*, Brightwell. Frustules hemispherical. Horns proceeding from the centre of the circular end; very stout and long, and beset with short spines, recurved.

* I am also able to state, that *C. Wighamii* and *Goniothecium hispidum* have lately been gathered in the bay of the Isle of Roa, near Ulverstone.

In guano from Callao, occurring in small flakes or patches full of pieces of the horns, and a few detached frustules. Plate VII., figs. 16—18.

§§§ *Horns proceeding from a cingulum or ring, dividing the frustules.*

10. *C. Wighamii*, Brightwell. Frustules cup-shaped, with a band round the mouth of the cup, and a neck or bulb, proceeding from the centre Frustules beset with minute short spines, or papillæ, in all parts, except the band. Oval, on a front, or end view, the spines appearing as minute specks. Boiled in acid, the filaments break up, and the frustules, in an isolated state, and detached rings, with the horns proceeding from them, are all that can be detected. The rings may readily be distinguished from the frustules seen endwise, as they are open, and without dots; while the frustules, seen endwise, are dotted.

In brackish water, near Breydon, Great Yarmouth. Plate VII., figs. 19—36.

We have named this species after the discoverer, Mr. Wigham, an excellent practical botanist, indefatigable in the pursuit of his favourite study, and most liberal in his communications to his friends.

11. *C. crenatum.*
12. *C. hispidum.*
13. *C. navicula.*
14. *C. barbatum.*

All these species are described or figured by Ehrenberg, from frustules found in a fossil, or deposit state, and appear to belong to this section of the genus *Chætoceros.**

The *C. Wighamii* was, as before stated, found near the salt-water estuary, called Breydon, at the point where the rivers Yare and Waveney meet. It occurred in a gathering made from a dirty ditch of brackish water, at the back of a small public-house, called "The Burney Arms," which is marked on the Ordnance maps. The gathering abounded in *Campylodiscus clypeus* (a species chiefly known before as occurring in fossil earth from Bohemia), and in one or more species of *Mastogloia*; it also contained *Bacillaria paradoxa*, *Amphora salina*, *Navicula palpebralis* and *tumens*, *Melosira varians* and *subflexilis*, and the *Ulva bullosa* (?); and *Protococcus hæmatodes* (?) abounded also in it, with which last the *Chætoceros* seemed most associated. It was perhaps parasitical on some Algæ, and, after being detached, had floated to where it was discovered. This place has been frequently visited since Mr. Wigham's decease, and searched in vain, for the *Chætoceros*; although most of the above species

* We subjoin a reference to the figures of most of the species above referred to, given in the Plates to Ehrenberg's Microgeologie.

Mastogonia . .	prætexta,	Plate XIX.	15.
Goniothecium . .	Rogersii .	Plate XVIII.	92.
,, . .	odontella	. . . .	94.
,, . .	gastridium	. . . .	91.
,, . .	didymum	. . . .	104.
,, . .	navicula	. . . .	105.
,, . .	hispidum	. . . .	107.
,, . .	barbatum	. . . .	106.
,, . .	crenatum,	Plate XXXIX.	2. 74.
Chætoceros . .	didymus,	,, XXXV.	A. XVIII. 4, and XVII. 5.
Xanthiopyxis . .	cingulata,	,, XXXIII.	XVII. 18.
Chætoceros . .	diploneiis	. . . .	XVIII. 1.
Syndendrium . .	diadema,	Plate XXXV.	A. XVIII. 13.
Dicladia . . .	capreolus,	. . . .	A. XVIII. 18.
Omphalotheca . .	hispida	. . . .	A. IX. 4.

were met with. In the living species of *C. Wighamii*, the endochrome was seen of a green colour, and aggregated in the centre of each frustule, in the manner represented in the figures of *Encampia zodaicus*, in Kutz. Bac., Pl. XXI., fig. 21, and Pritchard's Infusoria, Pl. XIII., fig. 43. No appearance of conjugation has been observed, nor have we been able to detect in this, or any other of the species, mentioned in this paper, which have come under our observation, any striæ, or markings of that kind.

We have detected most of the species above described in guano (chiefly from Callao), and especially in little transparent flakes or patches containing a mass of frustules. *C. gastridium*, *incurvum*, *Wighamii*, and *Peruvianum* are of most frequent occurrence.

There can be little doubt that all the guano of the coast of Peru is in like manner pervaded with these organisms, and if so, we ought to look to this locality for living species. *C. Wighamii* has, as we have already stated, been lately gathered in Monterey Bay, and a careful search would probably bring other species to light.

The discovery of a number of specimens of *C. boreale* in the stomach of a large species of *Holothuria*, or Sea-Cucumber, should lead to the examination of the stomachs of Sea-Slugs, especially of such as are known to feed on marine Algæ, for specimens of this singular and interesting group of Diatomaceæ.

Observations *on the* Practical Application *of the* Microscope. By J. Hepworth, Esq.

There are yet some parties in the medical profession who are sceptical as to the utility of the microscope. I have found it occasionally of practical importance; and perhaps if I mention a few cases, it may not be uninteresting to the medical readers of the 'Journal.'

J. M., a young man, aged twenty-three, applied to me, bringing, in a bottle containing some fluid, a lock of hair, and stating that he had vomited it in the night; that he believed it had been in his stomach three months, during most of which he had been under medical treatment for almost constant vomiting, and he thought this had been the cause. I examined the hair, and from the fact of the bulb and sheath being complete, I concluded it had not been in the stomach at all, or the gastric fluid would have dissolved these portions of it. I suggested that it might have been thrown into the vessel into which he vomited: that was found to be the case, on inquiry, although he left with an impression that

I was mistaken. To my surprise (in so young a man) I found abundance of *Sarcina Ventriculi* amongst the secretions attached to the hair. I prescribed, and the man got well in three weeks. Had I not accidentally made the discovery, he might have gone on vomiting three or six months longer.

J. W., aged twenty-eight, complained of great pain and irritation on micturition, and stated that he passed great quantities of matter. On examining the secretion, I concluded from its appearance, together with the symptoms, that the matter it contained was pus; but with the aid of the microscope I found it to be triple phosphate. I mentioned this case to a friend, a (microscopical) sceptic, who observed that I might have ascertained that by chemical analysis. I admitted it; but such a tedious process would have taken up too much time; whereas, with the instrument, I convinced myself of the fact in a few seconds, and was able *immediately* to give an opinion as to the probable result. I may further state, that the man, although so young, had lost all his upper teeth, and the first step towards his improvement was to procure an efficient set of these necessary articles: this he succeeded in doing (thanks to the dentists), and there was a gradual return to health, which I attribute more to the dentist's skill than to any other remedy.

T. V., a boy five years old, had general anarsarca after scarlatina: there was a brownish deposit in the urine. On examination I found it contained altered blood discs (having the appearance of toothed wheels), triple phosphate, abundance of casts of the *tubuli uriniferi*, and, I thought, a few pus globules (they might be mucous), but no brown epithelial scales, which is a usual accompaniment with casts, as far as I have remarked. The urine coagulated on the addition of nitric acid. These appearances told a tale, which could not have been so fully known without the aid of the microscope.

I received from a friend a substance stated to be a portion of a concretion passed per anum by a patient at the Manchester Infirmary: the case was one of Dr. E. Wilkinson's, who has kindly furnished me with some particulars, a few of which I shall state. R. L., ætat fifty-two, a weaver, four years ago began to complain of pain in the stomach and right side; it was so severe at times that he could not retain the erect posture: soon after he perceived a fulness in the side, the tumour gradually increased, and about two years ago

he, with severe pain, passed a hard, flattened, spherical concretion, of a light-brown colour, about two inches in diameter. His diet consisted principally of *oatmeal* and milk. The tumour still remains, and occupies a large portion of the abdomen. The concretions (of which he has passed several about the same size and character) appear to consist of compact masses of the beard of the oat.

Mrs. G. brought her son, a boy four years of age, who, she feared, had got the itch: the eruption appeared suspicious, but did not occupy the usual situations on the body. With a small pair of curved scissors I snipped off a pustule, in which I detected two ova of the *Acarus Scabiei:* this settled the matter at once.

This leads me to state that I have never seen a good representation of the mandibles of the *Acarus.* In a large and beautiful engraving, in the possession of a friend, there is only a slight indication of teeth up the centre of the head, as though the mandibles were single members. Having recently mounted a specimen, which shows the part so well, I have given a drawing (Plate VIII., fig. 3); also the mandibles of some other *Acaridæ.* A mandible consisting of a single member, appears, so far as my observation goes, to be the exception and not the rule in the *Acari.*

The mandibles of *Acarus* of the domestic Fly (fig. 6) appear to be a pair of simple forceps; whilst those of the Water Rat (fig. 14) seem to be a combination of forceps and scissors. There are two *Acari* of the Mole (which has its peculiar Flea, also), one (fig. 11) with the mandible furnished with four barbed hooks, and the other (fig. 12) with only a single hook, similar to that of the rabbit (fig. 13). All the other specimens have double crab-like members.

On a Case *of* Green Pigment-Degeneration *of the* Heart. By Dr. Thudichum.

In March last I gave to the Pathological Society of London an account of a case of green pigment degeneration of the heart, which has been published in the sixth volume of the Transactions of that Society. In a foot-note on p. 141 of the Transactions, I stated that I had since had an opportunity of examining the heart of a man, aged fifty-four, who died of disease of the brain (apoplexy from atheromatous arteries), which presented features analogous to those described in my first observation.

This case I have thought myself justified in recording at full length in this Journal, together with some observations on the present state of the question.

The *aorta* was in a state of atheromatous degeneration, with numerous scales of calcareous deposits.

The *left ventricle* was *hypertrophied* to an enormous extent, the walls being nearly an inch in thickness. The microscopic examination gave the following result:—

The muscular fibres from the outer wall show a granular deposit of a dirty-yellowish colour. The granules are of all sizes and shapes (Plate IX., figs. 1, 2), with a dark outline when well focussed. Their colour is deeper in some parts than in others; in some places it is a pale, dirty-yellowish tint, in others sap-green. The granules are deposited in patches, length-lines, mostly in the axis of the fibre, or singly, scattered about, all apparently inside the sarcolemma. The patches are very often broad and at regular intervals, so that it seems as if they represented transformed nuclei (fig. 2 *b*), particularly as the nuclei themselves are broad, nearly square, with rounded-off angles (fig. 2 *a*). In some places the deposit is principally conspicuous at both ends of a nucleus (fig. 2). The fibres themselves have preserved their transverse striæ; numerous length-lines run along the fibres parallel with their long axis, and crossing the transverse striæ, which thence appear as if they only reached from length-line to length-line (Plate IX., fig. 1).

Acetic acid dissolves the fibres, and leaves the nuclei and the unchanged granular deposit conspicuous.

Though the muscular fibres have a greenish tinge when lying in thick layers, yet this tinge disappears when they are lying singly, and when acetic acid is added, then all tinge, except that of the green corpuscles, disappears.

The septum atriorum showed less deposit in its fibres, which were however more macerated; its striæ were scarcely distinct as such, but gave the fibres an irregularly-shaded granular appearance, like figs. 2, 3.

In one of the *right trabeculæ* where the fibres are most friable, and break into debris on preparation for microscopic examination, the general tinge is deepest, but the deposit, though consisting of many granules, is not very conspicuous, because the granules are very small.

The *right ventricle* is in a state of atrophy, in every respect the reverse of the left. The walls are thin, flabby, and tear like rags. Their fibres are atrophied, pale, and very friable; great masses of fat-cells, or oil-drops, and globules of all sizes are scattered through their tissue. *Smaller fat-drops of the*

usual bluish-white colour, with the dark outline, are seen inside the sarcolemma along with the fine granular deposit. The fat, or oil-drops, from the largest to the smallest (fig. 3 *b*), *become beautifully conspicuous on addition of acetic acid, and so do the granular-yellowish and green corpuscles* (fig. 3 *a*), which thereby manifest themselves as being a distinct deposit, *and not a deposit of fat*, as encountered in what is commonly called fatty degeneration (fig. 3).

A small specimen boiled in ether showed the solubility of all the fat globules in ether, since the granular-yellowish and green deposit remained unchanged. On the ether cooling and acetic acid being added, oil-globules were precipitated again. They adhered to certain projecting parts, or along the nerve fibres, which had the appearance represented in fig. 5, evidently from the fat of the contents of the fibre having been dissolved and deposited again out of the solution against the walls of the fibre. Before boiling with ether the nerves had the usual appearance represented in fig. 4. This proves that mere boiling with ether is not sufficient to remove all fat, but that subsequent washing with repeated small portions of hot ether is necessary in order to remove all fatty matter. The few drops of ether in which the specimen had been boiled, which were clear when hot, became turbid after cooling, and under the microscope showed myriads of oil-globules of a more equal size, and molecules, of which the globules were being formed. None of the oil-globules deposited from the ether were tinged in any way, and the muscular fibres retained their greenish tinge after boiling, and preserved unchanged the yellowish or green deposit. This peculiar degeneration of the heart has been observed by Wedl ('Elements of Pathological Histology' pp. 171, 227), and by Kölliker, quoted by Wedl. Both call the deposit *pigment*, on account of its "dirty-yellowish" colour. What relation there exists between this pigment and "the tapering groups of small, isolated, yellowish granules," seen at either end of the nuclei of the fibres of any healthy heart, as described by Mr. Paget ('Surgical Pathology,' vol. i., p. 128), is a question to be answered by further investigation.

The report on my first specimen given to the Pathological Society by Drs. Habershon and Bristowe, and printed at pages 142 and 143 of the 'Transactions,' though admitting the correctness, on the whole, of my description of the microscopic appearances, is to the effect that the specimen described by me does not differ from the ordinary run of cases of fatty degeneration. The reporters did not find the molecular deposit greener than the fibres, and the latter pre-

sented so very faint a greenish tinge, that they should have passed it unnoticed, had not their attention been specially directed to it. They believe the molecular deposit to be neither green nor pigment, but simply fat. I believe that this discrepancy with my account may be explained by the following circumstances. The patient died on March 10th; I made the post mortem examination on March 13th, which was on a Tuesday. From the day following I had the heart under examination in a warm room during four successive days. On Saturday 17th I intended to give an account of the specimen to the Medical Society of London, but was prevented from doing so, and on that evening the heart went into the hands of Dr. Routh, who put it in spirits of wine, as it was already decomposing by that time. Happily I had on that day exhibited specimens under the microscope to several friends, all of whom found the molecular deposit to be green, one of them, Dr. A. Henry, so much so, that he deliberated with me, what appropriate name could be given to the deposit. Dr. Gibb recollects to the present moment, that he distinctly saw a green molecular deposit in the specimen submitted by me to his inspection. The artist, who made the diagram which I exhibited to the Pathological Society in illustration of my paper, coloured it after specimens under the microscope. The eye of this gentleman is perfectly achromatic, and practised in the minutest distinction of colours. On the other hand, my microscope is equally achromatic. On Tuesday, March the 20th, the specimen was, by the kindness of Dr. Quain, brought before the Pathological Society.

Already, on that evening, I could not succeed in showing the green colours under the microscope, because, as I then thought, the light was too yellow and too strong, being condensed by Gillet's apparatus. But I now believe that it was mainly due to the colour having been changed by decomposition and extracted by spirits of wine. After the meeting of the Pathological Society, the specimen, with several others, was put into strong spirits of wine, and it was only from the 21st downwards, eight days after the post mortem, that the specimen, in spirits, could be examined by the reporters. I therefore humbly submit that their report was not based upon the original appearances, but upon a specimen changed by the united influences of putrefaction and spirits of wine.

On the 24th I gave to Mr. Brooke, of Keppel Street, a mounted specimen for examination. He submitted it to an eminent microscopist, who declared it was nothing which he had not seen before. I requested Mr. Brooke to look at it himself, and he kindly did so in my presence, using per-

fectly white light for illumination. Though in many parts the green colours had entirely faded, the specimen being mounted in water, yet Mr. Brooke found clusters of molecular deposit, the colour of which he declared to be green beyond any doubt. He was quite positive about that. Even when he used a second power in the place of an eye-piece, which arrangement affords an exquisitely high magnifying power, and with a careful adjustment affords a beautifully clear view of the object, the colour of the clusters of molecular deposit appeared to him (and to myself) perfectly green. Two days after there was only a vestige of the deep-green colour left; it had decomposed, and dissolved in the fluid surrounding the specimen.

I have gone to such length, because, if the report of Drs. Habershon and Bristowe stands unexplained, either my veracity or the correctness of my sight might be doubted, and for either I should be very sorry indeed. But happily there are some witnesses to the green colour of the deposit before it was decomposed, and to this fact my character and that of my eye look for protection.

Already, in the note to my paper in the 'Transactions' at the Pathological Society, I have recorded my opinion on that degeneration, the produce of which, said to be fat, does not dissolve in ether. There is no fat, either in the vegetable or animal kingdon which does not dissolve in ether and volatile oils (Lehmann, 'Theoretical Chemistry,' 3rd edit, p 273.) It is, therefore, an error to call a deposit fat which does not dissolve in ether.

Since I saw green pigment for the first time, I have examined a great number of hearts and found green pigment in three more instances. In one case where the colour was most conspicuous, I was afforded a good opportunity of witnessing how quickly the green colour is changed by decomposition. It was in June; the heart stood for two days on a plate, covered by a saucer; on being uncovered it was found to be in the first stage of putrefaction, viz., smelling badly, covered with greasy matter and exuding brown serum. The green pigment was found to have changed its colour into a dirty earth-brown, and only here and there a faint indication of the former colour could be distinguished.

I think it only just to say that my paper was read and the report thereon given, before I was aware or it had been stated that Wedl and Kölliker mention a similar deposit. Corroboration of my observations is accumulating. Rokitansky, at p. 189 of the new (3rd) edition of his 'Pathological Anatomy,' speaks of granular pigment deposited in striated muscular

fibre, which is undergoing fatty degeneration. At p. 217 he mentions rusty brown granular pigment in muscular fibrils, which have lost their striæ, and in the atrophied muscles of a stump after amputation.

I hope to resume the subject in some future number of the Microscopical Journal.

On the ACTINOPHRYS SOL. By J. WESTON, Esq., H.E.I.C.

HAVING during the last two or three months met with a plentiful supply of *Actinophrys Sol*, and fortunately also a most unusual deficiency of professional calls upon my time, I have been enabled to pay these little creatures considerable attention, not, I hope, quite fruitlessly, since the description I am about to give of some of their peculiar habits will, I think, be novel.

I would premise, that as my knowledge of the microscope is in its infancy (something less than two years old), my observations will be confined mostly to *what I have actually seen* and shown to some of my friends, leaving deductions to older hands and abler heads.

I regret that I shall have to call in question the correctness of descriptions given by previous writers; but as I "pin my faith on no man's sleeve," and have rather a method of looking and thinking for myself, I shall fearlessly state what the instrument has revealed, much of which differs so materially from a Paper on the same creature in the 1st volume of the Journal, that I am led to imagine the writer and myself have been observing a different species.

In the first place, then, as there appears to be doubt about the existence of a valvular opening, I have had some thousands of these animalcules under my observation, and have never met with a specimen where the valve was absent. It is best distinguished when about the edge of the *seeming disc*, and so far as my observations go, is never still night nor day; being slowly, but without cessation, as it were, protruded, occupying from ten to seventy or eighty seconds in its development, and then, like the bursting of a vesicle, rapidly and totally subsiding; for an instant it has utterly disappeared, only to be again as gradually and as certainly reproduced. Should that side of the creature, where the valve is placed, be turned from the observer, *the effects* of the contraction are distinctly seen, although the valve itself is not, for at the instant of its burst-

ing and closure, some half-a-dozen or more of the tentacles, *situated on or about it*, which have been gradually thrust from their normal position by the act of its protrusion, now rapidly approach each other with a jerk-like motion, caused by the sudden bringing together of their bases.

With one-eighth of an inch objective I have been led to imagine the valve to be formed of a double layer of the external hyaloid membrane, the edges of which appear to adhere to each other tenaciously, notwithstanding the growing distension from within, until the force becomes so great that the lips, as they may be called, suddenly separate, apparently to give vent to some gaseous product, and at this moment there is, as I have stated, enough seen to induce the belief in the existence of a double lip-like valve, *perhaps the organ of respiration.* A rough sketch,* Pl. IX., fig. 6 *c.*, shows the valve distended. The power employed was two-thirds objective, and No. 2 eye-piece of Smith and Beck.

The mode of feeding in the *Actinophrys Sol* has not, I think, been accurately given. That the tentacles possess some other power than that of mere prehension appears to me evident, because nearly every creature of moderate, and sometimes immoderate size, which strikes against them, is at once, for a time, rendered immovable; when a Rotifer, in crossing the field with velocity, strikes against an object, the rotatory organ is frequently seen quickly to suspend its operation, the more particularly should its cilia strike the cilia of another animalcule; frequently no notice whatever appears to be taken of the shock, except a sudden change in its course; not so, however, with the victim to the *Actinophrys Sol*, on the instant of contact with whose tentacles it appears paralyzed.

In some cases the prisoner is held for some seconds on the exact spot where it struck, and then, without any visible means, becomes *attracted* towards the body of the *A. Sol*, gliding slowly down the tentacle until it is jammed between its base and a neighbouring one. In another instance (in the same creature) instead of the prisoner being arrested on or near the extremity of the tentacle at which it strikes, it is shot down to the base with extreme rapidity, to occupy the same position as in the former case. In a third it would seem as if the appetite of the *Actinophrys* were sated, or that the prisoner was not approved of, for after remaining stunned, sometimes for a few seconds, four or five, sometimes much longer, ciliary motion (of a Vorticella, for instance) is feebly commenced internally, not with sufficient energy to produce motion, but, as

* We are unable to obtain the assistance of an artist here, or the sketches should not have been *rough*.

if a return to vitality were being effected by struggles; shortly it is seen to glide off the tentacle (as if this appendage possessed the power both of appropriation and rejection), and frequently, with but little sign of recovered life, it slowly floats out of the field.

We have now arrived at the point where the intended food is fixed, the next process is as follows: from the margin of the body of the *Actinophrys* a thin pellucid membrane is projected, up the side of the creature destined for food, which proceeds rapidly, but almost imperceptibly, to surround one side of it; a similar membrane springs sometimes also from the *Actinophrys*, but more frequently from the tentacle on its other side; these amalgamate on the outer surface of the prisoner, which is thus enclosed in a sac, composed of what I take to be the extended outer vesicle of the *Actinophrys.* This vesicle gradually contracts, or rather seems to return by elasticity to its original position, and the food thus becomes pressed within the body, there to become digested.

Often before the engulphing was complete, I have seen the return of ciliary movement in the victim, which, when large, exhibits powerful efforts to free itself. This ciliary movement continues long after its total immersion in the body of its devourer, and ultimately ceases as its substance seems to be dissolved.

In no one instance have I ever seen that crossing of the tentacles described by Kölliker, as one of the means of preventing an escape, but, as I before said, I may have been watching a different species. In many instances I have seen half-a-dozen or more prisoners attracted to the tentacles of an individual, each gradually absorbed, and although thus busily occupied, *no cessation of the action of the valve takes place.* The *Actinophrys* itself appears as if possessed of the most complete stability; nothing seems to move it, a free Vorticella, almost as large as itself, or a Rotifer of equal dimensions, dashes against it, producing scarcely a sign of motion, although the force of the concussion would lead one to expect the little creature would be forcibly driven from its position. Does this stability arise from its *spherical figure*, and the hold thus given to it by the numerous tentacles arising from its entire periphery?

Fig. 6 *a* of the sketch is intended to show a *Chætonotus larus,* engulphed; *b, b, b,* three Rotifers fixed between the tentacles; *c,* the valve. Power used, 2-3rds objective, No. 2 eye-piece.

Fig. 7 *a* represents a large Vorticella, seized and surrounded

by the outer membrane, previous to being drawn into the body as food. Power used 1-8th objective, No. 1 eye-piece.

Fig. 3 is my best drawing with the camera lucida; which, bad as it is, will, I hope, show, *a, a,* two Vorticellæ enclosed within the vesicle. To obtain this, with my untrained manipulation of the camera, I had to raise the stand of the microscope a foot from the table. The power used was 2-3rds objective, and No. 2 eye-piece. A very few minutes sufficed to engulph these larger morsels.

With regard to the reproduction of the species, I can positively affirm that self-division is one mode, for I may say I have witnessed it a hundred times, and shown it to others. The first time it came under my observation was late in the afternoon, early in the month of August last; division had commenced before the object came into view, but in less than an hour it was complete. The observing of this act by a more experienced microscopist than myself would, I have little doubt, set at rest the question as to whether or no the envelope of the *Actinophrys Sol* was cellular. I watched this division proceed, as in fig. 4, which was sketched about half an hour after first seen. First was noticed a deep depression above and below, not far from the centre of the body; this, as it increased, threw the tentacles across each other, in a manner similar to that described by Kölliker, when in the act of enclosing an object of prey; this crossing, however, in the act of self-division would appear to be only the necessary consequence of the depressions alluded to in the sketch, and the position into which the outer membrane (in which the tentacles are inserted) is drawn. As division proceeded, the two animalcules steadily, but rather quickly, increased the distance between them, until the connecting medium was apparently a long membranous neck, which, to my unpractised eye, appeared composed first of four, then three, then two, irregular lines of cells (possessing no nuclei), which ultimately diminished into a single cord, composed of three simple cells, elongated like the links of a chain, this becoming gradually more attenuated, until the exact moment of its division could not be seen. All this latter portion of the process was rather rapidly performed, that is, from the first formation of the rows of cells, to the time of what I supposed to be the final separation, occupied only about a quarter of an hour.

At this time *only the margin* of each *Actinophrys* was left in the field, so rapidly had they receded from each other; so that, to watch further, I had to shift from one to the other; this, however, could only be done for a very short time, as they got out of an easy line of observation, which made it necessary

I should confine myself to one, and I selected the larger of the two. Attached to the side of this I could perceive two of the cells which had previously formed the connection, and on the loose edge of the outer was a floating faint line, the broken thread; this, together with the cells, gradually contracted towards the body, and only a few minutes were necessary to draw the whole into the body of the *Actinophrys*, which then appeared as perfect an animal as I had seen. During the whole of the process, the valve of each, situated at nearly opposite extremes, was in constant action, and each creature was busily employed seizing its food.

On the following morning I had several specimens in a cage, one of which I observed *slightly* indented on its opposite sides. I wrote to a microscopic friend to come to my bungalow (only about two hundred yards separated from his), but before despatching the note I took another look, and found division progressing so rapidly, that I fixed the cage and carried the instruments to him.

Precisely the same proceedings occurred that I have already described, except that the connecting chain, previous to separation, remained to the last, broader, consisting of five or six rows of cells. I have since had so many opportunities of witnessing the same circumstances, that I have written down self-division in the *Actinophrys Sol*, *as a fact.*

That other modes of multiplication occur is, also, I consider, undoubted, otherwise how are to be accounted for the clusters of them in their infancy, frequently met with so minute as to render a $\frac{1}{4}$ inch necessary to identify them positively; minute, however, as they are in this stage, the valve is still to be easily recognised when the eye has become accustomed to its motion.

With regard to the production of these clusters of young I have a curious occurrence to register. I have observed, and that by no means unfrequently, see fig. 5 *b*, *b*, a thin pellicle protruded from the edge of the *Actinophrys*, sometimes forming a single, large irregular-shaped sac, generally two, as in the figure, and in one instance, three. The first time this came under my observation I supposed the cover of the cage was pressing too hard upon the specimen, and was crushing it, for shortly both cells simultaneously burst at their outer margin, giving exit to a considerable mucous discharge, much resembling (only of less consistence), the discharge seen on the bursting of pollen; this discharge diffused itself gradually in the water of the cage, and steadily disappeared (in eight minutes) on dilution. Immediately after the bursting of these cells I was surprised to see them contract; this changed my opinion regarding the supposed pressure of the cover, and

I soon became satisfied it was a natural phenomenon, for with the same slow and steady motion by which all the food is drawn in, and in the same manner as the connecting medium of self-division, after separation, so were the burst cells drawn towards the *Actinophrys*, ultimately disappearing in its substance. I kept this creature under the microscope nearly the whole day, and watched it constantly, feeding it as in all other cases.

Naturally expectant of a repetition of this proceeding, I had soon the satisfaction of seeing it (for I had on some occasions thirty or forty specimens in the cage at once), and have watched the process as I have described upwards of a dozen times.

Does this emitted fluid contain the germ of future generations?

In Buffon's 'Histoire Naturelle' he says that nature gives to the *Actinophrys Sol* a mouth and an anus at opposite sides of the body. These I have never seen, nor anything that leads to a conclusion of their existing, for the food is admitted into the body exactly at the base of the tentacle against which it strikes; so also are the excrementitious portions of the food passed out at any spot where circumstances appear to force them. This latter process I have frequently seen; in one specimen twice, in less than half an hour, at different spots.

In watching the digestion of a Rotifer, it occurred to me to see a dark body, composed apparently of the case, remain for some hours in the same spot, and then gradually approach the side, as if for expulsion, but while waiting for this to take place, an opening in another part occurred, and excrement was voided in quantity; this voided matter lies amongst the base of the tentacles, while the opening through which it has passed closes, and then, with the same stealthy motion I have before described, it is apparently driven along the tentacles (as if by repulsion) beyond their extremities, finally disappearing in the surrounding medium.

I am aware that Pritchard gives the *Actinophrys Sol* "a flat, pancake form," p. 554, but this I look on as an error. If the cover of the cage in which the specimen is confined be gradually and dexterously raised a little, with a 2-3rd objective, and No. 2 eye-piece, the animalcule may be made to take a rolling motion, owing to the increased depth of water, and its spherical form distinctly traced; moreover, correct focussing with the higher powers will give the very points of the tentacles standing erect, which, by *focussing down*, may be traced to their bases, while, during the progress, the points

and sides of others come plainly into view with the *rising* of the globe.

With an 1-8th objective I can distinctly see granules in constant motion in the body of the *Actinophrys*, similar to those always found in the points of the *Closterium Lunula*. Apropos to this, a microscopic observer here remarked to me, a short time since, that these granules, in the hyaline globules at the points of the *C. Lunula*, are dependent for their position in the globule *on gravity*, being always found, when observed through the compound body, in *the upper portion* of the field. Repeated observations of my own confirm this, which has not, I think, been hitherto noticed.

In conclusion, I have much to regret that my attempted description of the actions of the *Actinophrys Sol* is sadly deficient in a most essential point, viz., the absence of any measurement of the objects. Microscopists are, as yet, but few and far between in India, and there is not a micrometer here; even the instruments furnished lately by Smith and Beck for the use of the Government hospitals are deficient in this essential, added to which is the distressing circumstance, that we are so far from the manufacturers that what could be procured in London in a few hours, or at most a few days, I have been waiting for with the greatest anxiety since October, 1854, in which month I sent an order for them.

Sept. 10*th.* Since writing the above I have had another case of self-division, which presented some novel circumstances.

I had been observing a specimen which was an unusually large one, when visitors interrupted me. At the end of an hour or so, on returning to my table, I found that division had proceeded almost to completion, for the two were each partly out of the field. I was using Smith and Beck's ¼ inch. For a time I observed them to become stationary, which is not usual at this stage, but I was greatly surprised presently; a *reflex action* commenced, and instead of separation, they rapidly approached each other by the contraction or elasticity of the neck or chain. Not only did they close upon each other, but the smaller specimen overlapped the larger with full one-third of its body, and thus they remained still for about two minutes, giving me hopes I should be able to confirm Kölliker's description of amalgamation; but here I was disappointed, for again they parted, the same chain appeared to elongate, and that so rapidly, that in about five minutes they were perfectly divided, and both out of the field.

Again I followed the larger specimen, because within it

could be seen a large green oval substance, approaching to the outer edge as if for expulsion. This occurred in about half an hour, but in a manner perfectly distinct from any I had before seen. In this case the egg-shaped substance, fully one-fourth as large as the *Actinophrys*, was pushed through the integuments, retaining its perfect figure, and giving to the whole object much of the form of a dumb-bell crystal, only that the one portion was smaller than the other. Suddenly, as if from distension, the envelope of the ejected substance burst, the ovoid figure was instantly dispelled, the greenish matter of which it consisted spread about similarly to the excrementitious ejections, and quickly disappeared.

Does this remarkable oval figure support the supposition of the cellular substance of the *A. Sol?*

In other words, was it a single cell distended with fæcal matter?

Was the conjunction of the two partially divided specimens accidental, or had it ought to do with gemmation?*

* The following letter accompanied the above interesting paper:—

"Dear Sir, "*Bangalore, Sept.* 10, 1855.

"I hope you will find the enclosed worthy a place in the 'Journal.' It strikes me that we are yet in our earliest stages of knowledge of the *Actinophrys Sol.* Each specimen I look at shows me something more that I have seen before, and the difficulty of developing the cause of its motions appears to me greater the further I go. I have seen a specimen this morning fixed in a fork of the plant, as it were in an angle, thus *forcibly work itself out*; but by what means I could not distinguish. The valve was posterior in its progress; has this anything to do with it when under such fixed positions? In this case the body of the *Actinophrys* was forced forwards, so as to leave the tentacles as it were trailing behind against the sides of the angle out of which it forced itself. It has, at the moment of my writing, been four hours in an open space, feeding voraciously, but not moving. Indeed, it has not gone beyond the field of the $\frac{1}{4}$-inch, since it took up the position.

"I have a curiosity for a future occasion, in the shape of a Rotifer hitherto unknown, with a forked foot *and a tail.* I was fortunate in getting a brother officer to take a better sketch for me than I could do myself. I fancy it allied to *Hydatina.*

"If I can in any manner be of service in India, I shall be most happy.

"I remain, dear Sir, very truly yours,

"*To Dr. Lankester,* "J. Weston."

&c. &c.

TRANSLATIONS.

On the Impregnation *and* Germination *of* Algæ. By M. Pringsheim. (Abridged from the Reports of the Berlin Academy.)

(Continued from page 72.)

Having thus fully described the mode of origin of what may be termed the sexual organs in *Vaucheria*, the author proceeds to describe the process of impregnation as it takes place in the *Fucaceæ*, and which he finds to be of a precisely analogous nature. Adverting to Thuret's observations and experiments, which showed that unless brought into contact with the *antheridia* of the male plant, the spores of these plants invariably perish without germination, he proceeds to relate his own researches on the same subject in *Fucus vesiculosus*. The result was fully to confirm Thuret's statements.

The density and opacity of the contents of the so termed spores in the *Fucaceæ*, render them much less fitted for microscopic examination than are those of *Vaucheria*, nevertheless the author arrived at some important conclusions.

In *Fucus vesiculosus*, however, it is not the spore which is impregnated. The so-termed spore of this plant is a large thick-walled cell, densely filled with granular contents, and supported on a unicellular peduncle. When mature the contents of this spore divide into eight segments, which the author terms "division-spores" (Theilsporen). When arrived at this stage the contents of the spore are expelled from the transparent thick spore-membrane, and through the opening of the conceptacle (Hüllenfrucht). This usually takes place when the plants have been left dry by the retreat of the tide. Under the same circumstances the antheridial sacs of the male plant are also ejected through the opening of the conceptacle.

When the tide returns and the plants are again covered with water, the *antheridia* burst exactly as described by Thuret and Decaisne, and allow the mobile spermatozoids to escape, which spread themselves in all directions, and reach the "division-spores" which have collected themselves around the orifice of the conceptacles in the female plant. These sporules, which at the moment of their escape were imbedded in a common gelatinous matrix (fig. 21), have in the mean while become

isolated by the disappearance of the jelly. It will then be seen that each sporule is also surrounded by a very thin colourless gelatinous layer (fig. 22); and it will be distinctly perceived that these eight portions of contents of the original cell have not as yet acquired any cellulose membrane. Should any doubt upon this point remain, it will be wholly dissipated upon close consideration of the two lowermost sporules in their natural position, and which are the last to leave the spore-case when its contents escape (fig. 21 *a*). These two portions are always produced at the extremity into a point, which shows the absence of a membrane with the greater certainty, since the change of form into the spherical, which these spores undergo when they become isolated, could not take place did any membrane exist. The spermatozoids, then, come into contact with these membraneless masses, covered only with a thin gelatinous layer. It is these masses, the "division-spores" of the *Fucus*, which after impregnation has been effected become the young plant. The first indication of commencing germination in them is the formation of a visible, tough membrane (fig. 23) around them, which also manifestly arises from a transformation of the gelatinous layer in which they are enveloped. The membrane is apparent about twenty-four hours after the contact with the spermatozoids.

So soon as the membrane is formed around the sporules, a number of minute *red-brown nuclear bodies*, which did not exist before, are visible at the periphery of the sporule, and *they are enclosed together with the mass of the sporule by the newly-formed membrane with whose inner surface they are in contact*. The author never failed to observe these minute, red-brown nuclei (fig. 23), in impregnated sporules which afterwards grew up into young plants. They make their first appearance almost simultaneously with the formation of the membrane at the periphery of the sporule, and do not disappear till afterwards, and in the further development of the impregnated sporule (fig. 24). The author looks upon these corpuscles, whose colour corresponds with that of the nuclei of the spermatozoids of *Fucus*, as originating in the spermatozoids.

The present case, therefore, he remarks, affords another instance of what was observed in *Vaucheria*, viz., that the act of impregnation does not consist in the operation of the spermatozoids upon *a previously perfectly-formed cell possessing a membrane*—an "embryonic cell"—which would be impregnated through its membrane, but rather in this, that one or several spermatozoids enter a still membraneless, granular mass, which afterwards, together with the spermatozoids,

acquires a membrane, and thus comes to represent the vegetable embryonic cell capable of immediate development.

The parent-spore in *Fucus* and the *sporangium* in *Vaucheria*, are morphologically equivalent to the central cell of the *archegonium* in Ferns and Mosses, to which the canal of that organ leads, and to the embryo-sac of phanerogamous plants. The author has hitherto in vain sought for an embryonic cell before impregnation has taken place, in the central cell of the *archegonia*. But, on the contrary, is pretty well convinced that in this case also the true embryonic cell is not formed around a portion of the contents of the central cell until *after* the entrance of the spermatozoids, and that it encloses the spermatozoids which have thus effected their entrance. May not the same process take place also in phanerogamous plants? May not the point of the pollen-tube which enters the embryo-sac enclose the spermatozoids, which together with the contents of the embryo-sac become the cell of the embryo, which is not developed until *after* impregnation?

After noticing the obvious analogies, thus indicated, between the process of impregnation and the probable mode of origin of the *first* embryonic cell in animals and plants, the author goes on to speak of the sexual organs in the *Florideæ*.

He says that his own observations, which fully agree with those of Thuret, Mettenius, Derbès, and Solier, show that Nägeli was in error in stating that the *antheridia*, or cells so termed in the *Florideæ*, contained spiral filaments. These organs, however, are nevertheless true *antheridia*, and the absence of spiral filaments in them only show what was evident in *Fucus* and *Vaucheria*, that the existence of spiral filaments can no longer be regarded as the sole morphological proof of the male function of an organ. On the contrary, it is indisputable *that there are several forms of self-moving corpuscles which, in plants, exercise the function of spermatozoa.*

Besides the spermatozoids of the Ferns, Mosses, Characeæ, &c., which approach in conformation the animal spermatoza, we are at present also acquainted with forms more nearly approaching zoospores, as in the *Fucaceæ;* and, lastly, with that, differing from either, peculiar to the spermatozoids of *Vaucheria*, whose nearest allies would perhaps be met with among the Lichens. But the cells of the so-termed *antheridia* of the *Florideæ*, manifestly resemble in the most striking manner the spermatozoids of the *Fucaceæ*, and still more those discovered by the author in *Sphacelaria*, which, in their structure, appear to constitute an intermediate form between the two. This correspondence in structure, renders it in the highest degree probable that these organs constitute the true

male sexual apparatus of the *Florideæ*, although they possess so little motile power. As far as regards the antheridian cells of *Polysiphonia*, the author can only confirm what is stated by Thuret. "I noticed," he says, "it is true, a gradual emptying of the originally full *antheridia;* but I observed the isolated antheridian cells close to the *antheridium* from which they had escaped, free indeed, though always motionless." Like Thuret and Mettenius, the author has never been able to perceive the cilia described by Derbès and Solier.

Another question equally important with the discovery of the *antheridia*, concerns *the existence of organs in the Florideæ which are impregnated by the antheridea, whose existence has been thus certainly proved.*

The author has been unable to solve this question, which he proposes as a very interesting subject for botanists residing constantly at the sea-side. He has endeavoured, however, by observation of the germination of tetraspores, and of the conceptacular spores of *Ceramium rubrum*, to approach its solution.

But few observations upon the germination of the *Florideæ* have been published, and an essential defect pervades the few that have been made, owing to the circumstance that observers have been satisfied with the development of a few cells from the spore, and have not sought to inquire whether the growth proceeding from the spore resembles the parent plant or not. In order to determine this point, those plants are undoubtedly the most favourable whose laws of growth are known, and the author therefore instituted his researches on the spores of the species of *Ceramium*, because he had investigated the formation of the stem of the *Ceramia* with the accuracy requisite for an inquiry of the kind. For this purpose, it is sufficient to know, with respect to the mode of development of the *Ceramia*, that they grow with a terminal cell, from whose continued horizontal division the separate joints arise; and that the first cells of the so-termed cortical layer arise from the formation of oblique walls which are developed in the cells constituting the joints, in a direction from above and inwards, downwards and outwards; these first cortical cells then subdivide repeatedly, and thus constitute the cortical tissue surrounding the central series of cells.

Now, the tetraspore of the *Ceramium* in its germination, follows the mode just pointed out, from its first division onwards. It is itself the first apical cell of the future plant, as is shown by its longitudinal multiplication in the same way as the other apical cells, and in the indications of the formation of the cortical cells in the mode above described. The

product of its germination is therefore indubitably a young *Ceramium*.

But it is otherwise with the conceptacular spore. From this arises a very irregular cellular growth, which in form and mode of origin, exhibits no similarity whatever with the body of the *Ceramium*.

From this conceptacular spore is manifestly produced a *prothallus* (Vorkeim), and it only remains to inquire whether this production is equivalent to the *prothalli* of Mosses or to the *prothallium* of Ferns. As the author has often seen the commencement of germination in the still *closed* conceptacular fruit of the *Ceramia*, without noticing any entrance into it, it appears to him not improbable that the impregnation of the *Florideæ* takes place in the prothallus arising from the conceptacular spore; unless it may be, that the *Florideæ* with closed conceptacular fruit, may behave differently in this respect from those whose conceptacles have a canal leading into the interior.

Though his researches have been very incomplete, he sees reason to believe [with Harvey and Thwaites], that the tetraspores of the *Florideæ* represent only gemmules of the sexual multiplication, whilst the conceptacular spores are either the true female sexual organs of those plants, or at any rate produce a structure which exercises the female sexual function in some way or another.

Among the *Fucoideæ* of Agardh, the existence of *antheridia* in the true *Fucaceæ* (*Angiospermeæ*, Kützing) is no longer an isolated fact. A second instance of *antheridia* filled with mobile spermatozoids, in structure and mode of development far more closely resembling the *antheridia* of *Fucus* than those observed by Thuret in *Cutleria*, was discovered by the author two years since in *Sphacelaria tribuloides*.

The terminal cell of *Sphacelaria*, which, during the youth of the branch as a vegetative organ, forms the joints by repeated horizontal division, when the branch has attained to a certain age, suddenly ceases to divide; it enlarges considerably, and constitutes the organ, closely filled with contents at the apex of the older branches, and which has been termed by algologists the *sphacela*. This *sphacela*, which is always terminal, is in fact nothing more than the enlarged terminal cell of the ramule. It is precisely the same also with the terminal cells of those peculiarly metamorphosed lateral ramules, which are known as the propagative buds (brutknospen) of the *Sphacelaria*, and which are capable of becoming new plants by direct growth. Within this transformed cell on the common branches, as well as on the propagative buds, are after-

wards formed one or several large cells, which do not usually include the whole contents of the *sphacela*. These cells are the *antheridia* of the *Sphacelaria*, and their contents, at first brown, gradually lose all colour and appear indistinctly organized, assuming the aspect of a fine-granular, mucoid substance, obscurely subdivided into separate, roundish, colourless corpuscles, and closely resembling the contents of the *antheridium* of a Moss previous to its opening.

Shortly after the *antheridium* has reached this stage of development, its membrane is suddenly protruded on one side into a long tubular prolongation, which breaks through the wall of the *sphacela* (fig. 25) and opens at the point. At the same time an active struggling and swarming movement in the contents of the *antheridium* begins to take place under the eye of the observer; and it is seen that the indistinct organization presented in the contents of the unopened *antheridium*, was due to the existence of closely-packed, minute, colourless corpuscles, crowded into the narrow space.

Most of these corpuscles quickly escape, and quite isolated from each other, through the tubular process, moving spontaneously and freely with great rapidity in all directions. Those left in the *antheridium* now having more space, exhibit a distinct locomotion, although less rapid than that of the corpuscles which have made their exit.

In the spermatozoids left within the *antheridium*, the author has observed motion for more than an hour, whilst the escaped spermatozoids cease to move after a few minutes.

The movement of the spermatozoids, though in some degree like that of zoospores, appears to differ in this respect, that the motion of zoospores is more uniform and continuous, and that of the spermatozoids interrupted and jumping.

The spermatozoids of *Sphacelaria* appear like very minute, clear cells without any dark or coloured *nucleus*, and so far present the most striking resemblance to the antheridian-cells of the *Florideæ;* but, on the other hand, they are furnished with two cilia, like the spermatozoids of the *Fucaceæ*, like which they move very actively. They appear, therefore, to constitute an intermediate form between the spermatozoids of the *Fucaceæ* and those of the *Florideæ*, though as regards the development of the *antheridia* within a single cell, and the mode in which the *antheridium* opens, they are manifestly more nearly allied to the former.

The author has little hesitation in assigning the female sex to those plants which bear lateral sessile spores, but does not seem to have confirmed this by direct observation. He remarks that it is very probable that *Sphacelaria tribuloides* also

affords *zoospores*, which escape from the cells forming the joints; but of this also he does not appear to have any certain proof. He describes *antheridia*, precisely like those of *Sphacelaria* and developed in the same way, in the terminal cells of the lateral ramules in the closely-allied *Cladostephus spongiosus.*

With respect to the fresh-water Algæ most nearly allied to *Vaucheria*, it is, perhaps, sufficiently clear from the author's observations on that species, that these plants, besides the asexual, gemmate multiplication by zoospores, also present a true sexual propagation. The most probable supposition would be that the *female organs* of these plants, as in *Vaucheria* are to be sought in the *quiescent-spores*, which have been found in many genera. But in the next place it remains, not only to discover the *antheridia* in these plants, but also to show the possibility of the *entrance* of the spermatozoids into the interior of the quiescent spores, through an *opening in the spore-membrane;* or as in the *Fucaceæ* the impregnation of the sporules externally to the parent body.

The author's observations on these points, though incomplete, may still be serviceable towards further research.

The asexual multiplication of *Achlya prolifera* is well known, but besides the zoospores this plant also presents quiescent spores contained in peculiarly shaped *sporangia.*

The author finds that these spores germinate in the same way as do those of *Vaucheria.* He found also that before the formation of the quiescent spores, and in some measure simultaneously with the division of the contents into the masses destined to become quiescent spores, a great many minute, oval, sharply-defined openings are formed by the absorption of the cell-wall of the *sporangium* in several places, which constitute so many open passages into the interior of the *sporangium* even whilst its contents are in progress of formation into quiescent spores. The object of these openings is clearly to allow of the entrance of the spermatozoids into the dividing spore-mass. In this case, also, the action of the spermatozoids must be exerted upon the contents of the *sporangium whilst undergoing division* and *not* upon *perfectly-formed* spores, for, long after the openings have been formed, the segments of contents of the *sporangium*, are not even separated, and far less do they represent fully-formed cells.

This process of development indicates a great similarity between *Vaucheria* and *Achlya;* but whilst in the summit of the tube in *Vaucheria* a single large zoospore is formed, in that of *Achlya* very many smaller zoospores are produced, and the same is the case with respect to the quiescent spores;

whilst in the *sporangium* of *Vaucheria* only a single, large quiescent spore is produced which is impregnated through a solitary orifice in the membrane of the *sporangium*, in the *sporangia* of *Achlya* numerous smaller quiescent spores arise, and the supposed impregnation takes place through numerous openings in the membrane of the *sporangium*, whose number probably corresponds with that of the spores. The analogy between the two cases is further rendered more apparent by the existence of very slender ramifying branches springing from the parent tube in close contiguity to the *sporangium* containing the quiescent spores, and which are so closely applied to the membrane of the latter as apparently to be adnate to it. The analogy between these ramules which were first pointed out by Braun, and the "hornlet" in *Vaucheria* cannot be overlooked. The author has often noticed them, and it has appeared to him that where they were in contact with the membrane of the *sporangium*, these ramules throw out short papillary lateral shoots, which were protruded through the openings of the membrane of the *sporangium* and caused the close adhesion of the ramules to that body.

Although, at present, it is but a mere supposition that the spermatozoids of *Achlya* are developed in these armules, the existence of the openings through which the spermatozoids may reach and impregnate the contents of the *sporangium*, has at least been discovered; and it has also been shown that the quiescent spores of *Achlya* germinate in the same way as do those of *Vaucheria*.

Among other fresh-water *Algæ* which, besides the asexual mode of multiplication by zoospores, also present quiescent spores; the author proceeds to communicate some observations, made upon *Œdogonium*, *Bulbochæte*, and *Coleochæte*. With respect to the *micropyle* of the *sporangia* in *Œdogonium*. he remarks that before the formation of the spore in the parent cell, a great accumulation of its contents takes place as in *Vaucheria;* and on many occasions in *Œdogonium tumidulum*, he has witnessed the sudden *rupture* of the membrane of the *sporangium*, on one side, through which the granulous and cutaneous layers are protruded (fig. 26.) But the latter does not, as in *Vaucheria*, throw off a portion, but is again withdrawn; and the whole contents of the cell, not yet surrounded by a membrane, are converted into the well-known quiescent spore of *Œdogonium*, most probably with the co-operation of spermatozoids which have entered through the opening in the *sporangium* thus formed. The *opening* in *Œdogonium* is

smaller than in *Vaucheria*, and it represents an oval, sharply-defined slit (fig. 27).

The passage for the spermatozoids into the parent-cell of the quiescent spore of *Bulbochæte* is formed in a different way; in this instance the membrane of the *sporangium*, likewise in consequence of the accumulation of its contents, is also ruptured; but in a transverse fissure, more or less above the middle (figs. 28, 29), so that the membrane is split into two perfectly separate parts, between which the open passage to the contents of the *sporangium* is rendered possible.

The *openings* of the *sporangia* in *Œdogonium*, and the transverse fissures of those in *Bulbochæte*, both of which afford an open passage into the interior of the *sporangium*, being thus made known, a phenomenon common to both plants demands the closest consideration.

Besides zoospores and quiescent spores, a third kind of spores are met with in these plants, which are formed in smaller cells, widely different from the common vegetative cells (fig. 30*a*). To this kind of spore A. Braun has applied the name of "*microgonidia*," noticing, at the same time, that the product of their germination is merely very minute, usually bicellular little plants. These *microgonidia*, which present precisely the same structure as the zoospores, always affix themselves in a remarkable way, either upon the *sporangium* or close to it. In *Œdogonium* they are found seated sometimes upon the membrane of the *sporangium*, sometimes upon that of the cell immediately contiguous to it, and in *Bulbochæte* invariably upon the *sporangium* (figs. 28, 29, 30). Hence they open, either at once or after they have pushed out one or two short cells, and pour out their contents. Although, at present, no indication of spermatozoids has been observed in them, still the remarkable concurrence of the *evacuation* of these *microgonidia*, immediately over, or at any rate very close to the opening of the *sporangium* in *Œdogonium* and of the *transverse fissures* in *Bulbochæte* necessarily leads to the supposition that the contents of the *microgonidia* penetrate into the *sporangia*, and the author has no doubt that it will be found that the impregnating morphological elements of *Œdogonium* and *Bulbochæte* exist in the little plants produced from the *microgonidia*. But this impregnation in *Bulbochæte* and *Œdogonium* differs essentially from that which is observed in *Vaucheria*, for in the former case the two kinds of sexual organs are not produced upon the fully developed plants, but a special structure, a prothallus as it were, simply bearing *antheridia* is

formed, to act the part of an impregnating apparatus. And connected with this supposed diversity in the mode of *impregnation* is probably the difference observable in the mode of *germination; for the germination of the quiescent spores* in *Bulbochæte* differs very essentially from that of spores of *Vaucheria.*

The curious development of the quiescent spores of the former plant is thus described by the author.

The thick-walled, wholly *red* spore became green at the border, the innermost layer of the cell-wall expanded and burst through the outer layers and the membrane of the *sporangium.* Thus the spore escaped from the *sporangium* covered only by the innermost thin layer of the cell-wall, whilst the ruptured walls either opened out like two lids (fig. 31), or the upper portion was elevated upon the escaping spore (fig. 30). This liberated cell in a few hours was elongated into an ovoid corpuscle (figs. 32, 33), whose contents shortly afterwards were divided by successive scissions into four parts, lying one behind the other (fig. 33).

In one or other of these portions of contents might now be perceived a lateral, clear space (fig. 33), whilst the membrane surrounding the four bodies thus constituted became more and more expanded, lost its consistence, and swelled out into a kind of jelly. At the same time a faint movement was perceptible in the *four reddish-green bodies,* becoming more and more marked as the membrane expanded. The structure of the bodies was now sufficiently obvious; each exhibited a clear space at one end, around which was a crown of cilia (fig. 34); they moved about as far as the space would allow with great activity, with a continued vibration of the cilia, and an uninterrupted turning on their axis.

Thus in the interior of the quiescent spore four zoospores were produced, which presented precisely the same structure, and were of the same size as the *usual* zoospores of *Bulbochæte,* from which they differed merely in the circumstance that they contained, at any rate some of them, a red oil, similar to that with which the quiescent spores are filled.

These zoospores, when liberated from the surrounding vesicle, attached themselves and germinated. This production of four zoospores within the quiescent spore of *Bulbochæte,* recalls the similar process in *Chlamidococcus pluvialis,* and shows that the quiescent forms of the *Volvocinæ* should be regarded simply as quiescent algan spores resulting from sexual impregnation.

In various species of *Coleochæte* the formation of zoospores,

from the contents of the quiescent spore, may be observed to take place in pretty nearly the same way as in *Bulbochæte.*

Thus it will be seen that two modes of development of quiescent algan spores, resulting from impregnation, exist. Whilst in one mode, that which obtains in *Vaucheria* and *Achlya*, the quiescent spore is developed at once into a young plant; in the other, *Bulbochæte*, *Coleochæte*, *Œdogonium*, it is merely the parent of swarming zoospores, which grow into young plants by direct germination.

That similar sexual conditions occur in the *Palmellaceæ* is almost certain; at any rate, in them also the existence of red, quiescent spores together with zoospores is indubitable. Thus in *Glœocapsa ampla* the author found, besides the individuals whose cells become zoospores, other cells which acquire thick walls, and become filled with red contents. These forms have been erroneously regarded as distinct species. They are in fact the female individuals of the plant.

Researches are still very much wanted as to the sexual conditions of other *Algæ*, such as the *Spirogyræ* and *Desmidiaceæ* on the one hand, and the *Oscillarina*, Kutz. on the other, in which nothing like *antheridia* have been observed, although the author indicates the basilar cells in *Rivularia* as showing some indications of such being their nature. In conclusion, he thus sums up the result to which he conceives his observations have led:—

1. That the phenomena presented in *Vaucheria* and *Fucus*, establish beyond doubt the material co-operation of the spermatozoids in the act of impregnation.

2. With respect to the essential nature of the act of impregnation; it appears that the spermatozoids do not impregnate an already perfectly formed cell, but that the act of impregnation consists in this, that one or several spermatozoids enter the, as yet, membraneless contents of a cell; that this amorphous substance is not surrounded with a membrane until after the entrance of the spermatozoids, which membrane at the same time encloses the spermatozoids that have effected an entrance. The true embryonic vesicle, therefore, does not exist before impregnation, but is formed subsequently to that act.

3. With respect to the conditions attending the fructification of the *Algæ*; that a sexual propagation takes place in them as well as an asexual multiplication or gemmation.

The *asexual multiplication* is effected by means of the

tetraspores in the *Florideæ*, by the *prolifications* and *propagative gemmules* which are found in the *Fucaceæ* and the other *Fucoideæ*, and by the zoospores which are widely distributed among the marine and fresh-water *Algæ*. The sexual function is probably fulfilled in the *Florideæ* by the cells of the *antheridia* and the *conceptacular spores;* in the *Fucaceæ* certainly by the spermatozoids and the contents of the so-termed "spores;" in the *Confervæ* by spermatozoids and the contents of the quiescent spores.

The spores of the *Fucoideæ* and the *quiescent spores of the fresh water Algæ*, however, are properly spore-fruits (*sporangia*), whose contents are fertilized sometimes *within*, sometimes *without* the *sporangium.*

The *Algæ*, moreover, are sometimes *diœcious*—and this is the case with the greater number—some *monœcious.* The individuals, lastly, which form the *asexual* organs of multiplication are usually *sexually sterile;* but at the same time in their vegetative parts *more strongly developed* than the fertile; this holds good both of the individuals with tetraspores among the *Florideæ*, as well as of the individuals of the fresh-water *Algæ*, which form zoospores. The latter condition, which has as yet not been noticed, promises to afford much aid in the classification of allied forms.

On the Course *of the* Amyloid Degeneration. By Rudolph Virchow. (Abstracted from the Archiv. f. Patholog. Anatomie und Physiologie. Bd. viii., p. 364.)

In former communications on the subject of "amyloid degeneration" the Author was able to adduce, as instances of the affection, besides the *corpora amylacea* in the nervous system, only the waxy degeneration of the spleen, liver, and kidneys; but since then some more recent cases have afforded him the opportunity of extending his researches, and of making, as he thinks, a very important advance in the knowledge of the remarkable changes included under the term.

In all these cases there existed chronic, and very considerable disease in some part of the *osseous system.* Even in his former communication, respecting the "waxy spleen," he had noticed that it was especially in persons affected with chronic disease of the bones that this form of degeneration of the organ was presented, and he has since seen scarcely a single case in which the same complication did not exist. This frequent association cannot, he thinks, be explained except upon the supposition that the disease in the bone exerts a

determinate influence upon the production of the affection in the spleen, liver, and kidneys. It is usually the case that primary, long-continued disease of the bones, especially *caries* and *necrosis* of the larger bones or portions of the skeleton, in their subsequent course, induce cachexia and dropsy, and particularly *albuminuria* and degeneration of the kidneys, but how is the connexion between the primary and secondary affections to be explained? Two hypotheses, with respect to this, might be entertained, either the disease in the osseous system may so far interfere with the general nutrition that the constituent elements of the spleen, kidneys, and liver may be deprived of their normal supply of nutriment, and disposed to undergo the amyloid change, or the disease in the bones may actually produce the amyloid matter, which is deposited secondarily in the other organs. In the former case there would be a peculiar metamorphosis, an idiopathic, morbid change in the elements of the spleen, liver, and kidneys; and in the second an instance of metastasis, in which the glandular organs would be merely the seat of the deposition of the morbid material.

Hitherto Virchow has not found in the *bone* itself a substance corresponding to that which occurs in the abdominal glands, whilst he has always detected its presence in the *cartilages.* In an aged individual, who presented in many of the joints the changes peculiar to senile arthritis, the pubic symphysis in particular, towards the interior aspect, was much enlarged, and unusually moveable. When cut across, there was apparent in the middle of it an irregular, vertical fissure, with uneven, somewhat tuberous walls, and without any fluid contents. The layers of cartilage on each side were considerably thickened, of a dirty, yellowish colour, and very unequal density; the parts immediately contiguous to the fissure were more especially softened in places, greasy, and as it were, broken up, so that portions, of considerable size, were almost separated from the rest, or were held together only by slender connexions. Microscopic examination disclosed a great variety of constituents. The cartilage cells were generally enlarged, their capsules very thick and wide; in many places considerable-sized groups of them might be observed in a proliferous state, but in some might also be seen minute, roundish, or flattened corpuscles. Towards the surface of the fissure many cartilage cells were in a state of fatty degeneration, the matrix being, at the same time, transformed into a soft, clouded, streaked, and granular substance, in which the presence of cholesterin was here and there perceptible. In these situations the condition might be described as "*atheromatous dege-*

neration," similar to that which takes place in the arteries. Crystalline cholesterin existed only on the surface, beneath which, however, the matrix presented numerous alterations; isolated portions were composed, in great part, of the unchanged, hyaline, dense substance, close to which might be noticed considerable tracts and masses in which the matrix was streaky and fibrous. The fibres in some parts resembled the rigid filaments in the well-known asbestos-like portions of the costal cartilages, and in others assumed more the aspect of hard, wavy, and strongly refractive *striæ*. On the addition of solutions of iodine, either the simply aqueous, or made with iodide of potassium, some portions of the microscopic section at once assumed an intense reddish-yellow (iodine-red) colour, whilst others remained perfectly clear and colourless; the greater part presented a yellowish, and, on more prolonged action of the reagent, a yellowish-brown hue. If sulphuric acid or chloride of zinc be now added, the reddish-yellow spots are immediately rendered of a violet, or occasionally, bright blue colour, although a strong reddish tinge is always retained. Under the action of a very concentrated solution of iodine, also, the colour becomes at once dark red, or nearly violet-red, especially when the section so treated is dried and again moistened with water. The places in the section where the iodine reaction took place might be very distinctly recognized, even by the naked eye, as dark, reddish, or blackish-red points, particularly when thin sections were viewed over a clean, white surface. When examined with the microscope it was readily seen that it was not cholesterin in any form which afforded the simple reaction with iodine; as is usual, this substance, even after the addition of iodine, remained colourless, and did not exhibit any of the often-noticed changes of colour, except under the energetic action of sulphuric acid or of chloride of zinc.

It was now a point of much interest to determine in which of the structural elements the reaction took place; with respect to which it was at once evident that both the matrix-substance and the corpuscles participated in it, either each singly, or both, though less extensively, conjointly. Of the corpuscles, again, it was quite evident that it was the thick capsules which afforded the deepest colouring, which was intense in proportion as the corpuscles were of larger size, and more free in the surrounding matrix; but in some places the true cell (contents of the capsules) also appeared to be similarly affected; and, especially in the smaller ones, Virchow often noticed the entire corpuscles coloured red or violet throughout.

It was remarkable that no microscopic characters could be

discerned, from which it might be concluded *a priori* whether the parts would be acted upon by the iodine or not; neither in the matrix, nor in corpuscles, did the spots, which were afterwards coloured, exhibit before the addition of the iodine, any difference from those which remained uncoloured; nor, excepting the rather remarkable *microscopical* condition of the whole cartilage, could it be said that these cartilages presented any appearance by which they could be distinguished from many other senile cartilages in which the reaction did not occur. This circumstance, with regard to the cartilages, is perhaps of the more importance to be noted, as a strong contrast in this respect was presented in other parts, and especially in the glandular organs, in all of which, especially in more advanced stages of the affection, in the portions where the amyloid change had taken place, a degree of softening independent of any reagent might be recognised, and particularly the presence of a brilliant, pale, thickening substance.

A farther step in advance was made on the inspection of the body of a boy aged 13 years, who had died of albuminuria and dropsy, following *spondylarthrocasis*. In this case there existed almost complete destruction of the intervertebral substance between the last lumbar *vertebra* and *sacrum*, together with caries of the contiguous bodies of the *vertebræ*, and extensive sinuses passing through the sciatic notch and over the *crista ilii*, running far between the muscles of the buttock and thigh which were in a state of fatty degeneration, and opening externally by large fistulous orifices. No tubercles existed in any part, not even in the lungs; a single gland in the mediastinum only was enlarged, and filled with a cheesy, necrotic matter. On the other hand, there was very far advanced parenchymatous nephritis, with amyloid degeneration of the *glomeruli*, sago-spleen, and slight enlargement of the liver, whose cells, close to the portal vessels, were filled with fat, whilst the interior of the *acini* was occupied with amyloid substance. All the waxy parts of the spleen, liver, and kidneys afforded, with iodine alone, a distinct reaction, obvious even to the naked eye, and on the addition of sulphuric acid, a beautiful violet and blue colour.

The condition of the lumbar glands was especially worthy of attention. They were much enlarged, and presented externally a peculiar bluish-green, transparent aspect. On section, the medullary substance (*hilus*) appeared unchanged, whilst the cortical portion was more or less completely transformed into a clear, anæmic, transparent, nearly colourless gelatiniform substance. This condition was most apparent in the glands situated nearest to the diseased portion of the spine, and in

these it extended almost through the entire thickness of the cortical substance. Higher up the alteration was more confined to the peripheral portions of the glands in which the afferent lymphatics open, the substance surrounding the *hilus* and the inner portion of the cortical substance retaining their normal aspect. It could be readily perceived even with the naked eye, but still better with a lens, that the substance was not uniformly affected, but that the change had taken place in the points, which in a normal lymphatic gland, are visible as white, round, vesicular spots—the follicles or *alveoli*.

Microscopic examination entirely confirmed this supposition, and the chemical reaction fully established the identity of this morbid condition of the lymphatic glands with that formerly described by the Author under the term *sago-spleen*. In the lymphatic glands, as in the spleen, the follicles appear to constitute the proper seat of the affection, and in the one case, as in the other, the proper gland-cells (lymph-corpuscles) are destroyed in proportion to the amount in which the new substance is deposited. The follicles or *alveoli* enlarge at the same time, so as to attain to the size of a small pin's head, although the enlargement is never so considerable as in the splenic follicles. The deposited substance consists of comparatively large ($0 \cdot 04$—$0 \cdot 05^{mm}$), rounded, or subangular corpuscles, of a pale, colourless, homogeneous aspect, and breaking up under pressure in such a way that their solid structure is plainly discernible. In many cases might be perceived minute, superficial depressions, rounded or stelliform, and usually one or two in number, in which a minute, nucleiform body was often seen lying. Amongst them was spread a fine network, composed of stellate elements, in the nodular points of which 1—2 manifest nuclei were usually contained. Even on the simple addition of iodine the pale corpuscles assumed a beautiful yellowish-red colour, and on the application of a solution of iodine in hydriodate of potass, they were rendered distinctly bluish-red, which, on the subsequent addition of sulphuric acid, or of ioduretted chloride of zinc, became the most beautiful violet, gradually passing into a deep blue.

This degeneration, however, was not confined solely to the follicular elements, it being evident that the fine arterial vessels of the interstitial tissue had undergone a similar change in their tunics. They were thickened, and the lumen was contracted; whilst the walls, which appeared shining and almost homogeneous, afforded the most marked reaction. This change in the vessels, however, was also confined to the proper cortical substance of the gland; neither in the medullary substance, nor externally to the gland, was anything of

the kind observable in the blood- or lymphatic vessels. Nor in the interior of the gland did the vascular plexus there situated present any colouring.

This discovery is of considerable importance as regards the development of the *corpora amylacea.* On comparison with the figures given by Kölliker ('Mik. Anat.' ii. 2, figs. 365-367) of the normal lymphatic glands, it will be satisfactorily seen that each individual amyloid granule corresponds, not with a single cell, but with an entire group. For since the fine net-work remains in the interior of the *alveoli*, and, speaking generally, only one *corpus amylaceum* lies in each areola, it is obvious that it must represent an entire mass of the pre-existing cells. In this case, also, the amyloid degeneration cannot be regarded as a simple transformation of individual cells; as in the arterial vessels all parts of the wall—connective tissue, and muscular fibres—are ultimately fused into a homogeneous substance, so is it with the cells in the lymphatic follicles.

The morbid condition in the case last cited extended very widely upwards. The epigastric lymphatic glands were also extensively implicated, and on close examination some of the bronchial glands also exhibited scattered waxy spots, though it must be confessed to a very limited extent. At first it appeared as if the process in the blood-vascular system was limited to the minute arterioles of the lymphatic glands, spleen, and kidneys; but it was afterwards found that the arterial vessels of the digestive tract were also largely implicated.

Dr. Jochmann was the first to notice that a strong iodine reaction was manifested in the gastric mucous membrane, and further investigation proved that this commenced in the vessels, and was always most strongly marked in them. Further research showed the same alteration in the vessels of the mucous membrane of the œsophagus, and of the whole intestinal canal, but particularly in the small intestine. It was limited in all parts to the fine arterial vessels of the mucous membrane, or at most involved only those of the uppermost layer of the submucous tissue, and it might be traced to some distance into the arterial side of the capillaries. Without re-agents, little appearance of change was discernible, the only indication of it consisting in the circumstance that the walls were slightly thickened and homogeneous; on the application of iodine and sulphuric acid, however, a very deep, dark-violet colour was manifested, which never passed into such a beautiful blue as that presented in the lymphatic glands, but was nevertheless very characteristic. Simple

iodine even, also produced a very strong colouring. The change to the naked eye was not very striking. The mucous membrane in all these parts had a very pale aspect; and in the stomach and œsophagus it was somewhat thickened, unusually transparent, and in parts of almost gelatinous consistence.

The above case indicated a much wider range of the amyloid degeneration than was previously known, and another observation showed the reliance which might be placed upon the truth of the discovery. A man, thirty years of age, who had long suffered from necrosis of the *femur*, with sinuous abscesses and fistulous openings, died, also, with albuminuria and ascites, but not until a subcutaneous abscess of the scrotum, suppurative inflammation of the parotid, and hemorrhagic pleurisy had taken place. There was found an enlarged waxy spleen, and parenchymatous nephritis, with very considerable amyloid degeneration of the *glomeruli*, as well as of the vessels and *tubuli uriniferi* in the *papillæ*, together with simple fatty liver and atrophic induration of the pancreas. The right femur was the seat of extensive hyperostosis, combined in the inferior third with a great loss of substance, whence proceeded fistulous passages; the surrounding parts had undergone a thickening and condensation, such as is seen in "white swelling." The lymphatic glands in the thigh and groin were enlarged, of a clear grey colour, in parts more transparent. Microscopic examination distinctly showed the commencement of amyloid degeneration in the follicles, some of which were wholly reduced to that condition, whilst others still retained lymph-corpuscles in some of the *areolæ*; and others, lastly, presented nothing but minute *corpora amylacea* amongst normal corpuscles.

Virchow was unable in this case to detect any indication of amyloid degeneration in the heart or any part of the muscular system, even in close contiguity with the diseased bone; nor in the mucous membrane of the respiratory organs and kidneys. The blood, also, contained no morphological particles which could be pronounced to be *corpora amylacea*.

Nevertheless, with respect to the course followed by the morbid change, it appears indubitable that the incitement to it proceeds from the diseased bones, whence it extends progressively to the lymphatic glands, then to the spleen, and ultimately to several of the secretory organs. Among these the first to suffer are invariably the kidneys, then the liver, probably lastly the mucous membrane of the digestive organs; and it is a circumstance of the greatest interest, that both in the kidneys and in the digestive mucous membrane

the morbid change always commences in the secretory vessels, in the same way as in the lymphatic glands, the spleen, and renal *papillæ*, the vessels, and especially the arterial, are very early affected. In all cases the normal tissue is removed in proportion to the amount of the new deposit, and it is not the individual elements which degenerate each separately, but the change involves all equally, so that the ultimate products present a very uniform, homogeneous constitution. From all that appears therefore, it is highly probable that the affection consists rather in a metastasis of a material formed in the site of the original diseased action, that is to say, in the bones, and which is transported to the different parts in a state of solution.

The constitution of the deposit is not everywhere alike, as has been before remarked by Virchow ('Archiv. Bd.' iii. p. 144) and Meckel. In particular, it would seem, that the substance in cases of less complete deposition, though assuming a beautiful red colour even under iodine alone, receives only an indistinct violet tint on the addition of sulphuric acid, and is never rendered blue. This was the case very remarkably in a boy, fourteen years of age, affected with disease of the lumbar vertebræ, whose liver weighed 5 lbs. 13 oz., the spleen about 7½ oz., one kidney nearly 4 and the other 3½ oz.; in whom the entire parenchyma of the liver, the spleen in its pulp, the kidneys in the *glomeruli*, the afferent arteries, and in the *papillæ*, exhibited the most complete waxy degeneration. With sulphuric acid the iodine-red colour was deepened, but rapidly became of a dirty violet, or rather of a dark bluish-red hue, and in parts greenish. In this case, therefore, the substance existed either in a less perfect form, or was more mixed with other matters.

REVIEWS.

Untersuchungen uber den Bau und die Bildung der Pflanzenzelle. Von Dr. H. Pringsheim, &c. Grundlinien einen Theorie der Pflanzenzelle. Mit. 4. Colorirt. Tafeln. Berlin, 1854.

Researches on the Structure and Formation of the Vegetable Cell. By Dr. H. Pringsheim. (Notice from 'Bot. Zeitung,' May, 1855.)

This memoir, which constitutes the first part of researches respecting the vegetable-cell, is dedicated to the author's friend, Dr. F. Cohn. Its object is to afford a new doctrine and new views with respect to the primordial utricle, differing from those at present entertained. The author first proceeds to give an account of the primordial utricle, in accordance with which the principal part in the life of the cell is ascribed to that element which has been regarded as the essential, often the only completely closed, nitrogenous membrane of the plant-cell, and upon this subject the statements of some observers are communicated. A second section treats of the disposition of the contents of the vegetable-cell; these contents consist of the proper cell-fluid, which is always found in the interior, and of the external, peripheral, surrounding *protoplasma* (or more shortly, *plasma*), in which the granular portions of the cell-contents are always imbedded. A distinct lamination is apparent in this plasma, that is to say, it is constituted of an external, colourless layer applied to the cell-wall, and which never presents any granules, and termed by the author "the cutaneous layer," and of an internal, frequently of a dense mucoid consistence and granular aspect, "the granular layer" of the author. When this granular layer is of some thickness the chlorophyll granules will be found lying in its outer portion, whilst the inner part will be seen to consist merely of a colourless, muco-granular substance, in which, it is true, many kinds of colourless, coarse, granular particles occur, but never chlorophyll-granules or amorphous chlorophyll. The parietal cytoblast is invariably lodged in the "granular layer," and when this layer consists of two portions it is always found in the inner one. In cases where movement is observed in the cell, it always takes place at the boundary between the "granular layer" and the cell-fluid. When the granular layer is thin, the whole of it moves together with the chlorophyll granules imbedded in it, but when it is divided into two portions, the movement in-

volves only the inner layers beneath the chlorophyll-granules (*Chara*). The author supposes that the formative activity of the cell-contents is specially seated at the line of junction of the cell-fluid with the granular layer, and that it is the cause of the motion. In cases where the plasma does not constitute a continuous lining to the wall, it cannot, by means of re-agents, be detached from the wall with a definite outline, but in the shape of a variously formed net-work of streaks of plasma. But when it constitutes a complete and uniform covering, it contracts in a continuous form under the action of the re-agent, and under certain conditions assumes the false appearance of a membrane. Lastly, in cases where the plasma is divided, even in the cell, into two distinct layers, not only does the outer layer appear as a membrane, but the granular layer also presents a defined boundary. Whenever powerful re-agents are applied, and a rapid contraction thus induced, phenomena are always manifested, which necessarily lead to the assumption of the existence of a primordial utricle, although many different things have been included under that term. But when cells in which the primordial utricle is displayed in the most distinct form are treated with weak re-agents, although the same results are ultimately attained, the process, owing to the more gradual way in which it is effected, may be accurately observed, and it will thus be seen that it is not smooth membranes which are separated from each other, but a glutinous substance which is detached from a membrane to which it was adherent; the detachment frequently takes place only partially, and the connexion with the wall is maintained by isolated threads of plasma, which become more and more attenuated or are ruptured, until, at last, the outermost layer of the plasma, contracting, assumes the appearance of a membrane. This slow separation from the wall satisfactorily shows, in every case, that the internal coating of the cell is composed of a muco-glutinous, viscous substance, and that it is not, properly speaking, a *membrane*. The same considerations also confirm the author in his opinion that, when large cells are treated with slowly acting re-agents, the contents surrounded by the "cutaneous layer" often contract into two, or, more rarely, into several segments, whose connective portions becoming gradually attenuated are ultimately ruptured, and then isolated, though appearing to be bounded by an equally even and sharply-defined outline, as that of the whole contents previous to their division.

In the third section the author speaks of the cell-division in the *Confervæ*, noting, in the first place, its mode of occurrence in *Cladophora*, and afterwards in *Conferva*, *Spirogyra*,

and the Zygnemaceæ in general, in *Œdogonium* and the Palmellaceæ. Here also he endeavours to show that Mohl's view of the process of division is incorrect, and that it is manifested in the way he describes only when Mohl's mode of experimenting is closely followed. But when very dilute solutions are employed it is obvious that a delicate cellulose-septum exists even in the earliest stage of the division, and which was overlooked by Mohl. And further, that this delicate septum, is dissolved on the addition of acetic acid when the "cutaneous layer," together with the "granular layer," are detached from the proper cell-wall by weak re-agents (syrup); owing to which circumstance Mohl was unable to perceive this septum. The author recommends a dilute solution of chloride of zinc, in order to render the matter clear, from the circumstance that this agent first detaches the "cutaneous layer," the septum still remaining, though it is afterwards also destroyed. It remained to inquire whether this delicate septum were a single or a double membrane, and observations on other algæ (*Spirogyra*), as well as in *Cladophora*, when the division was interrupted, show that this wall is double from the commencement, arising from a portion of the innermost cellulose-layer thrown out towards the interior. Having discussed the mode of division of the cell in *Spirogyra*, and the Zygnemaceæ in general, the author proceeds to notice the process in *Œdogonium* and the Palmellaceæ, and finds that the cells of *Œdogonium* differ from those above described in the circumstance that the walls of the secondary cells are not applied closely to that of the parent-cell, and, consequently, that a different mode of separation is manifested in this case. In *Œdogonium* also a substance is deposited in places between the parent-cell and the uppermost secondary cell, in the form of a ring of cellulose. In the gelatinous *Algæ* the wall of the secondary cell is also not in close opposition with the parent-cell, a substance being deposited between the two in all parts.

In the fourth section, the import of the "cutaneous layer," as regards the cell, is shown. The subject of the author's researches in this respect was afforded by *Œdogonium*, in which plant the multiplication of the contents does not commence until the elongation of the cell is completed. In this case the accumulation of the plasma may be observed, and the "cutaneous layer" be seen to constitute an incomplete streaky lining of the cell-wall. The result of these observations leads to the conclusion that the cutaneous layer of the plasma is the same substance as that of which the cell-wall is directly formed, and that the transformation of the "cutaneous

layer" into the cell-wall takes place when the former has reached the highest stage of formation—that is to say—when it constitutes a complete parietal investment. The primordial utricle might, very readily, be taken for a membrane, but it is not a membrane distinct from the cell-wall, being merely its youngest cellulose layer, whose reaction with iodine depends upon the substances still adhering to it, since it is impossible that should be pure at this time. Usually it is only the outermost portion of the "cutaneous layer" which is intimately applied to the contiguous cell-wall, whilst the inner portion is gradually perfected, and eventually comes to be deposited in the same way. This just formed, youngest cell-layer also constitutes the folds which advance so as to effect a complete constriction in the interior of the cell. But it occasionally also happens that the innermost part of the "cutaneous layer" becomes a young cell-wall, in which case the outer portion is left enclosed between layers of cell-wall. In this way is produced the so-termed "jelly" in the Palmellaceæ, and the cellulose ring in *Œdogonium*. All these formations are merely slight modifications of cellulose, which, on the addition of acids, is either rendered blue by iodine, or is converted into a soluble compound belonging to the amyloid series, and which is not coloured blue by sulphuric acid and iodine. Consequently, when the latter phenomenon is not manifested in a membrane, the absence of cellulose cannot absolutely be assumed.

The mode of division of the parent-cells of the pollen is discussed in the fifth section. After giving a historical summary of previous observations on the subject, the author states the results of his own researches in *Allium Victorialis* and *Althæa rosea*, in which he finds precisely the same conditions to obtain as exist in the *Algæ*. The formation of the septum is similar, except that in this case it becomes thickened before it is completely closed.

The sixth section is entitled "Nature of the cell-division in plants." In this chapter the author shows that the capability possessed by the cell-wall of forming folds which are thrown out towards the interior is a general property of that tissue, and consequently that the act of division consists in the advancement of this plication till a complete constriction is effected.

In the seventh section it is shown that the free formation of cells consists in this: that the contents alone take part in the formation of the secondary cells, the membrane of the parent-cell having no share in it. But connected with this, various cases occur, which are more particularly specified by

the author. He then adverts to the "swarm-spores," which are said to possess only a primordial utricle, and is of opinion that the earlier limitation of these bodies is simply formed by the young cell-wall itself, which is unable to resist the powerful influence of re-agents, whilst at a later period, as the zoospore is more fully formed, it presents a stronger and firmer consistence. In a note, he remarks that the cilia of the zoospores are not motile organs, but for the purpose of attachment, and that the motion is induced in consequence of the perforation of the outer membrane, at which points a more active endosmosis takes place, as may be seen in the zoospores of *Œdogonium*, in which, when germinating, the opening through the outer membrane of the spore is always visible, from which the first commencement of the root proceeds.

The eighth section gives a *resumé* of the foregoing observations, and in the ninth the author adds a few supplementary remarks upon the methods to be pursued in researches of this kind, and particularly upon the application of chemical re-agents under the microscope, and with respect to the period at which the division of the cells in the *Conferva* may be best observed.

A Manual of Marine Zoology for the British Isles. By Philip Henry Gosse. London: Van Voorst.

A Handbook to the Marine Aquarium. By Philip Henry Gosse. London: Van Voorst.

Although the microscope is more capable of affording amusement than most philosophical instruments, there are few who have used it for any length of time but have discovered that it is an important aid in scientific research. Even those who have purchased their first instrument to wile away a leisure hour have gradually got interested in its structure, and the nature of the objects investigated, so that, although beginning in play, they have ended in work. No one can know that they have observed, for the first time, a fact new in the history of science, without the rising of the feeling that constitutes the discoverer in science—the seeker after truth. It is thus that many great microscopic observers have arisen among classes who have had no previous scientific education that has prepared the world for the result of their labours. The structure of the instrument, involving as it does the greatest mechanical accuracy with the most interesting problems of optical science, has excited the attention of one set of inquirers, whose labours have resulted in the

present perfection of the instrument. On the other hand, the habits of minute observation developed by the daily use of the microscope have produced a number of observers, whose contributions to science are known wherever its progress is regarded with interest. To those who are pursuing the latter path, all works on those departments of science to which the microscope is applied are of interest.

These two books by Mr. Gosse will be found useful additions to the microscopist's library. The Marine Zoology is the first part of a work devoted to the Zoology of the sea-side. To those who make a practice of taking their microscope to the sea-side, this book will be found very useful, for although it does not give an account of every species of animal to be met with, it gives descriptions of families and genera, and contains illustrations of above three hundred species. It is, however, only right to add that Mr. Gosse has omitted any description of the Infusoria, the only really microscopic family of animals. He excuses himself on the ground of the uncertainty naturalists are in as to the real nature and position in the animated scale of these minute beings. We miss also the Rotifera, but surely the same objections would not apply to giving an account of these animals.

One of the most useful adjuncts to the microscope is an Aquavivarium. Even a piece of *Vallisneria*, *Chara* or *Anacharis* in a jar will not only afford the materials for interesting observations in themselves; but the creatures that nestle in the leaves of these plants, and which live in the water they cerate, are almost innumerable. But what is true of these fresh-water plants and animals is also true of those of the ocean. With a little care, sea-weeds and marine animals can be kept as easily for observation as the plants and animals of fresh-water; but they require care, they demand knowledge; the domestication of Dulse and Sea Cucumbers is an art, and Mr. Gosse comes forward with a tiny hand-book of instructions for those who are ignorant and need a guide. From this book we give a short extract, by way of recommendation:—

In deep pools, and narrow clefts near the verge of lowest water, where the overshadowing rock excludes the sun's rays and imparts a genial obscurity, grow several of our most delicate and beautiful *Algæ*. Foremost among them is the Oak-leaved Delesseria (*D. sanguinea*), with tufts of crimson leaves, exquisitely thin, much puckered at the edge, and strongly nerved. The *Irida*, whose leaves are smooth and leathery, and of a dark-brownish scarlet, is often the companion of the former. Here, too, we find the *Phyllophora*, another weed of brilliant red hue, with unnerved leaves much divided, giving origin to other leaves, and these again to others. It is usually much covered with the cells and shrubs

of various species of *Polyzoa*, exquisitely beautiful objects for the microscope. The *Gelidium corneum* is another fine red weed, commonly of small size and slender, but prettily fringed with processes all round the edges of the leaves. This and the preceding are very hardy in confinement, and form very suitable plants for an Aquarium.

When we can no longer work at so low a level, we recede to the slopes of the ledges yet uncovered, and find other species in the quiet sheltered pools. A weed is found here, growing in dense mossy patches on the perpendicular and overshadowed edges of the rock, which, when examined, looks like a multitude of tiny oval bladders of red-wine, set end to end in chains. This pretty sea-weed is called *Chylocladia articulata*.

Here also grows the stony Coralline, a plant bearing some resemblance to that just named, in the peculiar jointed form of its growth. Low-lying pools are often incrusted with a coat of stony or shelly substance of a dull purple hue, having an appearance closely like that of some lichens; the crust investing the surface of the rock, and adhering firmly to it, in irregular patches, which continually increase from the circumference, in concentric zones. This is the young state of the *Corallina officinalis*, which by and by shoots up into little bushes of many jointed twigs, diverging on every hand, or hanging in tufts over the edges of the rock-pools. Young collectors are eager, I perceive, to seize such specimens as are purely white; but this condition is that of death; in life and health, the shoots are of the same pale purple hue as the lichenous crust. This plant in both states (for plant it undoubtedly is, though principally composed of lime, and of stone-like hardness) is suitable for a tank, as it survives and flourishes long; and your pieces of rock-work you may select from such places as are covered with the purple crust.

The most valuable plant of all for our purpose is the Sea Lettuce (*Ulva latissima*). Every one is familiar with its broad leaves of the most brilliant green, as thin as silver-paper, all puckered and folded at the edge, and generally torn and fretted into holes. It is abundant in the hollows of the rocks between tide-marks, extending and thriving even almost to the level of high water, and bearing with impunity the burning rays of the summer's sun, provided it be actually covered with a stratum of water, even though this be quite tepid. It therefore is more tolerant than usual of the limited space and profuse light of an Aquarium, where it will grow prosperously for years, giving out abundantly its bubbles of oxygen gas all day long. It is readily found; but owing to the excessive slenderness of its attachment to the rock, and its great fragility, it is not one of the easiest to be obtained in an available state. The grass-like *Enteromorphæ* have the same qualities and habits, but their length and narrowness make them less elegant. The *Cladophoræ*, however, are desirable; they are plants of very simple structure, consisting of jointed threads, which grow in dense brushes or tufts of various tints of green. Some of them are very brilliant; the commonest kind is *C. rupestris*, which is of a dark bluish-green; it is abundant in most localities.

General Outline of the Organisation of the Animal Kingdom, and Manual of Comparative Anatomy. By Thomas Rymer Jones. London: Van Voorst.

This work has long been one of the most complete in our language devoted to the subject of Comparative Anatomy. At the same time such has been the great advance of anato-

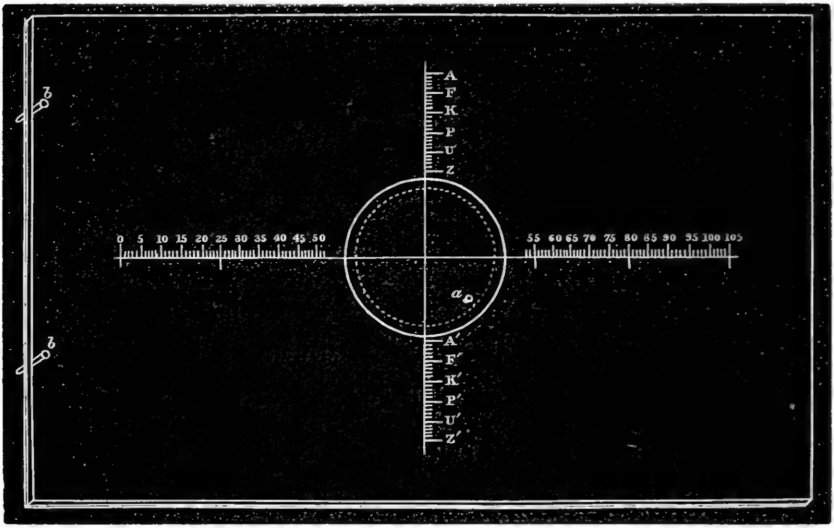
mical and physiological science, especially under the influence of microscopical observations, that a book never so complete in 1841 could hardly be regarded as a guide in 1855. It was, therefore, with pleasure that we saw announced a second edition, as in its plan and general arrangement we know of no other book so well adapted for the purposes of the general student. A glance at the present edition indicates that the author has added a considerable quantity of new matter. The plates, which were excellent in the first edition, have been increased from 330 to 398, and this even does not indicate the number of new plates, as many of the old ones have been withdrawn. The new matter, we find, consists principally of additions amongst the descriptions of the invertebrate animals, and of the history of their development. The student will also find in the account of the higher animals a very acceptable description of the homologues of the vertebrate skeleton. Professor Jones excels in the art of writing plainly and gracefully; and his additional matter, in point of style, is equal to anything in the original work. Had it been consistent with the intention of the volume, we should have been glad to have seen more of it re-written. Some of the old matter is getting quite old, and references to "recent" researches in 1841 should not have been left in an edition of 1855. We also find some indications of haste in the incorrect spelling and use of names. In spite of many serious deficiencies, and the absence of much information, especially with respect to the Protozoa and lower classes of animals afforded by numerous recent researches, defects in which Professor Jones's work is not singular, we can still recommend his Outline as one of the best introductions to the study of the animal kingdom that we at present possess.

NOTES AND CORRESPONDENCE.

Finders and Indicators.—Since Mr. Tyrrell first broached the idea of a finder, the subject has frequently engaged my attention, and although my own modification of his instrument enabled me with great ease to hit upon any object, however minute, even when using a plain stage to which the original was not adapted, I yet became early aware that a great improvement would be effected if the ivory slip could be altogether dispensed with; as it required, when using high powers, more steadiness of hand for its accurate use than many people are fortunate enough to possess, and as the reading the figures through the microscope was not always easy.

Dr. Wright's contrivance, which appeared in the same number of the journal as my own, was very satisfactory as far as the individual microscope for which it was used was concerned; but as no two makers form their instruments exactly on the same principle, it was inapplicable to a great number of moveable stages, although in the modified form suggested by Dr. Wright at the end of his paper, available for plain ones. It had, too, the disadvantage of being non-transferable (or "selfish," as Mr. Bailey calls it), from which charge, by the way, I must defend Mr. Tyrrell's and my own instruments, inasmuch as they formed very convenient packing cases for slides, and it was only necessary to wrap them in paper, and enclose them in a twopenny stamped envelope to insure their safe carriage to your correspondent. My own was suited for the use of any microscope, and was in this sense an "Universal Indicator;" its great drawback was, as I have stated, the ivory slip. I next tried the vertical and horizontal scales ruled on card, but failed from my inability to insure satisfactorily an uniform position for it on any and every moveable stage; in fact, the idea wanting was the ingenious one of Mr. Bailey—the separate central piece for continuing the vertical and horizontal lines to their intersection. The instrument which I now forward you (a rough and home-made specimen), and of which I also enclose an outline, is used with the greatest possible ease, and appears to me to possess the following advantages. Its steadiness is sufficiently insured by a side check to the left hand, which rests against the stage. The hole in the middle of the boxwood is furnished with a *rabbet* or ledge for the reception of a disk of bone, perforated accurately in the centre with a very small needle, and which can be *entirely* and steadily removed by seizing a little brass peg attached to it with the forceps.

There is no necessity for ruling the slides. The scaling is simple, and the cost of the instrument is very trifling.



Box-wood Finder, with bone centrepiece, *in situ*.

The dotted ring shows the *rabbet* on which the centrepiece rests.

a, brass pin attached to centrepiece.

b, two brass pins for steadying the instrument against the left side of the microscope stage.

N.B.—The scales may be ruled on brass or bronze and inlaid, and horizontal lines might be ruled on the surface of the instrument as a guide for placing the slide.

The following directions for its employment will be sufficient. 1st. Place the instrument on the stage, and find the central needlehole through the microscope. 2ndly. Remove the bone disk with the forceps held in the right hand. 3rdly. Place the slide on the wood (the named side always to the right), and make the requisite movements with the left finger and thumb, *not* with the stage screws.

The position of any object occupying the centre of the field will now be accurately marked by the sides and ends of the slide on two, at least, out of the four scales, and can be registered with a diamond point on the glass.

To find the object again is of course extremely simple—find your centre before removing the disk, and then place your slide according to the letter and number marked on it. As the boxwood should be at least an eighth of an inch in thickness, it would be an easy matter to excavate a space 3 inches by 1 inch on its under side for safely stowing away a slide in case of transmission by post or parcel.

Mr. Bailey alludes to the possibility of making the moveable stage its own indicator, but the old and ever obstinate vice of "selfishness" comes in his way, and he discards the idea in favour of his paper instrument, forgetting, as it seems to me, that his own very ingenious contrivance, the moveable centrepiece, is easily applicable to the stage. I would suggest, then, that if makers would rule their stages with the required vertical and horizontal scales of 50ths or 100ths of an inch, agreeing to adopt an uniform given distance from the middle for the commencement of each scale, and would supply an ivory disk, perforated in the centre for adjusting purposes, much would be done towards the attainment of a good "Universal Indicator." One trifling difficulty remains, it is this: the disk (as will be found on experiment) should not exceed 8-10ths of an inch in diameter, and the central apertures of microscopes are usually much larger than this. The simple remedy would be to furnish a metal or bone collar, which would fit the aperture, and remain in it while employing the finder. It strikes me, too, that as the scale divisions of less than 50ths of an inch may be puzzling to any but sharp eyes, and as finer divisions would certainly be advantageous, larger ruling might be adopted, and a small *vernier* made to slide in a groove by the side of each scale.—THOMAS EDWARD AMYOT, *Diss, Norfolk.*

On Micrometers applied to Microscopes.—The ordinary stage-micrometer, as constructed by the best English and foreign opticians, cannot be directly applied to the measurement of very minute objects. Although it can be procured at a moderate price, and with divisions beautifully ruled on glass at intervals of 1-100th of a millimetre apart, the scale is far too coarse for the use of the histologist; and it is usually quite impossible, in examining certain objects under high magnifying powers, to bring their edges into proper focus while the ruled lines of the scale continue tolerably defined.

The eyepiece-micrometer, consisting of a scale ruled on glass, and inserted in the stop or diaphragm of the ordinary negative eyepiece, is a very convenient instrument, enabling the observer, when using a magnifying power of 500 or 600 diameters, to estimate spaces of about 1-200th or 1-300th of a millimetre with tolerable precision, in favourable circumstances. But the breadth of the lines on the best ruled eyepiece-scale is so considerable, and the shadows caused by their channels so perplexing, even when the illumination is carefully managed, that, where extreme accuracy is required, other apparatus must be employed.

The cobweb screw-micrometer, when well constructed, is a far more perfect instrument; but, as Mr. Quekett remarks,

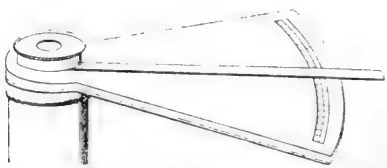
"the measurements made by it are by no means so delicate as they appear to be." In taking a unit, from which to construct the scale, a stage micrometer must be employed, and on the accuracy with which this is graduated depends, of course, the exactness of the subdivisions effected by means of the screw. This objection applies equally to all eyepiece-micrometers; but the screw-instrument has the positive disadvantages of being constructed of parts very apt to become deranged, and capable of being replaced by none but a first-rate workman. The effects of friction cannot be wholly obviated; the screw is apt to wear, and to wear unequally; and the uniformity of all its parts,—even when it leaves the workman's hands,—may be reasonably suspected. The price is necessarily so high as to preclude its general employment by those engaged in microscopic observations.

In Henle and Pfeifer's 'Zeitschrift für Rationelle Medicin' (band X. heft 1), Hermann Welcker, a medical student at Giessen, proposes a new kind of micrometer, capable of furnishing indications of extreme delicacy, and in elegance of principle and cheapness far surpassing the cobweb screw-micrometer.

The following description will enable any one familiar with the elementary principles of trigonometry to comprehend the mode of constructing and using such an instrument:—

Construction.—Across the stop of an ordinary negative eyepiece, two very fine threads, from a small spider cocoon, are stretched at right angles to each other, and, by means of a little copal varnish, are fixed in such a position that the shorter intersects the longer thread, cutting off about one quarter of its length. The relative position of the threads is shown in Figs. II. and III., where they are indicated by the letters A B and C D. To the upper part of the tube of the microscope is fixed transversely a brass plate, along which plays a pointer, firmly attached to the eyepiece immediately beneath its milled rim. The appearance of this apparatus is shown on a reduced scale in Fig. I. Upon the edge of the brass plate is drawn an arc of a circle concentric with the

Fig. I.



eyepiece, and this arc is then subdivided into degrees, and any fractional parts which may be required.

By experimenting with a stage micrometer, we next endeavour to ascertain how far the pointer must be moved, in order that the crossed thread shall traverse a space in the field corresponding to 1-100th of a millimetre. By simply manipulating on the stage of the instrument, the stage micrometer can easily be put into the position shown in Fig. II., the long line A B accurately coinciding with a line of the micrometric scale. The eyepiece is then cautiously rotated, till the cross in the field, passing along the imaginary dotted circle in Fig. II., seems to touch the next line of the stage-scale, the long line now assuming the position *a b*. The arc traversed by the pointer during this rotation is then read off,—we shall suppose it an arc of 8°. The *sine* of the corresponding arc of the dotted circle will, of course, indicate exactly 1-100th of a millimetre ; and from this simple foundation any measurement—*i. e.*, the length of the chord of any given arc in that circle—may be calculated ; for the chord of any arc being equal to twice the sine of half that arc, the value of the chord of 8° is found as follows :—

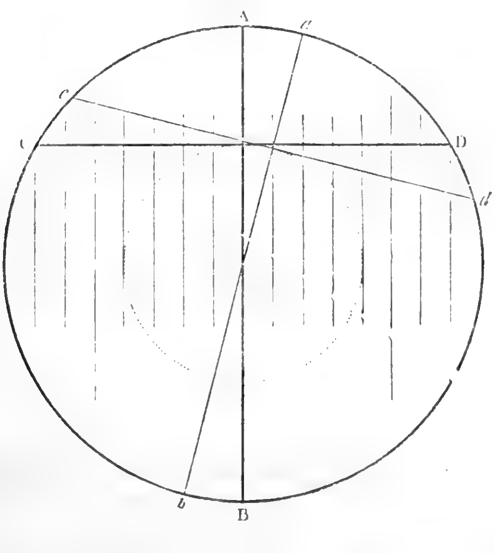
Proportion.

As sin. 8° : ·01 Millimetre : : 2 sin. 4° : chord 8°

Calculation.

Log. 2 sine 4°	=	9·1446145
Log. ·01 Millim.	=	2·0000000
		7·1446145
Subtract Log. sine 8°	=	9·1435553
Chord 8° = Num. ·0100244 Millim.	=	2·0010592

Fig. II.



The same result may be obtained from the following proportion, both sine and chord being supposed drawn :—

Proportion.

Rad. : ·01 Millim. : : secant 4° : chord required.

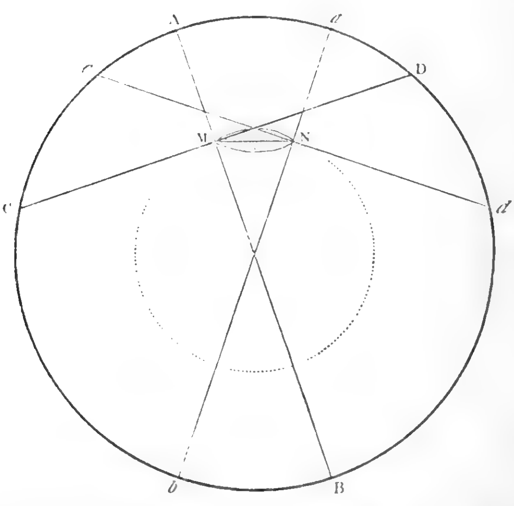
Calculation.

Log. secant 4°	=	10·0010592
Log. ·01 Millim.	=	$\bar{2}$·0000000
Subtract Log. Radius	=	10·0000000
Chord 8° = Num. ·0100244 Millim.	=	$\bar{2}$·0010592

The equivalent number ·0100244 is the required value of the chord of 8° in fractional parts of a millimetre. This or some other chord having been carefully determined by the instrument-maker, or observer, it should be noted down, as essential for the exactitude of all measurements to be afterwards made. It will save trouble if its logarithm be also recorded.

Mode of using the Instrument.—Suppose we wish to measure the long axis of an object, such as M N in Fig. III., we so arrange it on the stage that the cross in the field will, when the eyepiece is rotated, touch first the extremity M, and then the other extremity N. The arc A *a*, traversed by the

Fig. III.



pointer, is read off from the brass scale. The chord of the corresponding arc of the imaginary dotted circle is the measure

of M N. Its length may be calculated with the greatest ease by the help of the ordinary logarithmic tables of sines. In comparing chords, we use the sines of half their including arcs, as in the example which is appended :—

EXAMPLE.—See Fig. III.

The arc A a is found = 38°
Required the length of M N.

Proportion.

Sine 4° : ·0100244 Millim. : : Sine 19° : M N.

Calculation.

Log. ·0100244 Millim.	=	$\bar{2}$·0010592
Log. sine 19°	=	9·5126419
		7·5137011
Subtract Log. sine 4°	=	8·8435845
M N. = Num. ·0467861 Millim.	=	$\bar{2}$·6701166

In like manner the length of any other chords of the dotted circle may be easily determined; and a table—if required—drawn up, from which the measure corresponding to each degree of the scale can, by mere inspection, be at once ascertained.

When the eyepiece rotates smoothly in the tube of the microscope, and a magnifying power of 500 or 600 diameters is used, measurements may be made with such an instrument with the utmost nicety. Welcker recommends that the top of the tube of the microscope should terminate in a hollow cone, into which is received a conical collar, supporting the pointer, and slipt on immediately beneath the milled rim of the eyepiece. The errors of manipulation should hardly exceed 1-40,000th of an inch,—a degree of exactitude scarcely attainable by the cobweb screw-micrometer. An instrument constructed for me, by Mr. James Bryson, of Edinburgh, on the plan above described, has been tried against a finely-finished screw-micrometer, and found to perform with very great accuracy.—W. ROBERTSON, M.D., *Monthly Journal of Medical Science.*

Cilia in Unicellular Plants.—In consequence of several communications appearing in the 'Microscopic Journal,' announcing the discovery of the existence of cilia both externally and internally, in the *Desmidieæ* and *Diatomaceæ*, I have been induced to make a careful series of examinations of some of these objects, under all varieties of illumination, differences of aperture, and magnifying power.

From being somewhat limited in a supply of the *Closterium lunula*, I have used the *C. acerosum* as the chief subject of the investigation, from the fact that all the motile phenomena are precisely analogous, and quite as easily marked as in the other. I possess a white flint glass bottle (closed with a cork), containing an aquatic plant. The earth at the bottom is covered with a stratum of the *C. acerosum*, and each decaying stem of the plant, is also sheathed with a bright-green coating of the same, in a vigorous state of growth. Specimens in various stages taken direct from this source, were the objects observed.

In the *C. acerosum*, the endochrome and primordial utricle will sometimes be found partly contracted in a longitudinal direction, at the same time drawing the swarm-spores and vacuole with it; a considerable clear space is thus left at the end of the frond, wherein the motion of the protoplasm can be very distinctly seen in the act of flowing and returning in thread-like currents, which shift their position, and frequently take a spiral direction, in a manner exactly resembling the circulation in the hairs of some plants.

The vital protoplasm contained within the *Desmidieæ*, has a similar granulated appearance, and is endowed with the same active powers of locomotion as in other plants. Having then a tendency *per se* to run in rapid currents, why should the presence of cilia be requisite for assisting a motive force already sufficiently energetic? Without being prejudiced by any obvious reply to this question, I have tried to discover the presence of cilia, with the aid of the most perfect appliances that the optician's art can furnish, but without success. So far as eyesight will inform me, there are no indications of these organs either externally or internally—neither on the membrane of the primordial utricle, or as an investment, lining the inner wall of the frond—all the undulating motions and currents appear to be caused entirely by the movements of the protoplasm.

As I can, at will, adjust the illumination, conjointly with other circumstances, so as to produce the most positive appearance of moving cilia, not only internally, but also on the *exterior* of the frond, I will briefly mention the causes of this fallacy. The effect of oblique sunlight, or any other powerful source of illumination, in causing a refractive atom to appear elongated, as a ray or line, is too well known to need comment, as is the fact that this ray will appear to extend over the boundary of a cell-wall, or other adjoining body. Another cause of deception arises from a large angle of aperture; when a thin plane or membrane is viewed, in such a position as to be

parallel to, and coincident with the axis of the object-glass, the cone of rays will be bisected, and the opposite sides of the surface brought into the eye simultaneously: consequently, a somewhat confused definition is the result. A protuberance on one side will seem to penetrate and project through on the other side. With the aid of a diagram it would be easy to demonstrate mathematically the optical principle to which this appearance is due, but in the present case, a familiar example will, perhaps, suffice to prove the fact.

In viewing the circulation of the *Anacharis* with a large aperture, the chlorophyll granules traversing along a straight and thin septum, (if the position is favourable,) appear to project into the neighbouring cell, seeming to pass directly under the line of the cell-wall. Smaller particles will apparently travel within the substance of the wall, and in case of a boundary or single cell, or in unicellular plants if the surrounding water has nearly dried up, the rim or prism remaining round the exterior, causes irregular refracted images of the particles of protoplasm to appear *outside* the cell, bearing such a remarkable similarity to external cilia, that the passing shadows may even be mistaken for currents in the water; I do not say positively that these are the causes, giving rise to the appearance of cilia observed by others, I merely mention them as facts to be borne in mind.

I may also state that I have never been able to discover the orifice, said to have been seen at the extreme ends of the *Closteria*. It may be assumed that if such an opening existed it would have something like a structural margin, of such a size as to allow its position at least to be visible under the microscope, but not the slightest break can be observed in the laminated structure that the thickened ends display.

All attempts that I have made to ascertain the existence of cilia in the *Diatomaceæ* have been equally unsuccessful. How then are the active traversing motions of these organisms to be accounted for? If caused by the action of cilia, such extremely rapid impulses would be required, to propel the comparatively large body through the water, that surrounding particles would be jerked away far and wide; a similar effect would be observed if the propulsion was caused by the reaction of a jet of water; which, according to known laws of hydrodynamics, must necessarily be ejected with a rapidity sufficient to indicate the existence of the current, a long distance astern. I consider that there is no ground for assuming the motions of the *Diatomaceæ* to be due to either of these causes. They are urged forward through a mass of sediment, without displacing any other particles than those they immediately come

in contact with, and quietly thrust aside heavy obstacles, directly in their way, with a slow but decided mechanical power, apparently only to be obtained from an abutment against a solid body. In studying the motions of the *Diatomaceæ*, I have frequently seen one get into a position such as to become either supported or jammed endways between two obstacles. In this case particles in contact with the sides are carried up and down from the extreme ends, with a jerking movement, and a strange tendency to adherence; the Diatom seeming unwilling to part with the captured particle. Under these circumstances I have distinctly perceived the undulating movement of an exterior membrane; whether this envelopes the whole surface of the silicious valves I am not able to determine, nor do I know if the existence of such a membrane has yet been recognized. The movement that I refer to occupied the place at the junction of the two valves, and is caused by the undulation of what is known as the "connecting membrane." This will account for the progressive motion of the *Diatomaceæ*, which is performed in a manner analogous to that of the *Gasteropoda*. The primary cause, however, is different, and not due to any property of *animal* vitality, but arises, in my opinion, merely from the effects of *vegetable* circulation. I have observed several corpuscles of uniform size, travel to and fro apparently within the membrane, which is thus raised in waves by their passage. From this I, therefore, hazard a conjecture, with respect to the movements of the *Desmidieæ*. (Their progression is but seldom seen, and then extremely slow, and chiefly confined to elongated specimens, as the *Closteria*.) As there are no indications of either external orifices or cilia, may not their locomotion be effected by the currents of protoplasm forcing their way between the primordial utricle and outer tunic, which will thus be raised in progressive waves, if the investment happens to be in a suitably elastic condition?—F. H. WENHAM.

Remarks on Mr. Wenham's paper, on "Aperture of Object-glasses." —As Mr. Wenham now frankly admits the correctness of my statements with regard to the possibility of resolving difficult test objects, even when balsam-mounted, no further remarks are necessary upon that point, but a few words of comment are required by other portions of Mr. Wenham's paper.

That my reply was written before I could have had any knowledge that Mr. Wenham had recalled his remarks, in which doubt appeared to be thrown on my positive statement of facts, will sufficiently appear by the date of my reply, which was published in the 'American Journal of Science' for

January, 1855, the very time in which Mr. Wenham's retraction of his remarks appeared in the 'Quarterly Journal of Microscopical Science.'

If Mr. Wenham finds anything objectionable in the form of my reply, he should bear in mind that the discussion is not one of my seeking, and that I put the best possible construction upon his remarks which called in question the correctness of my assertions. I am utterly averse to anything like scientific controversy, and would make no further remarks in this connection, if Mr. Wenham had not so entirely mistaken my statement, as to represent me as having published sheer nonsense.

The statement on which Mr. Wenham animadverts is as follows: "The error in Mr. Wenham's arguments will be sufficiently obvious to any one who will trace the course of a divergent beam *out* of the balsam, instead of *into* it; and it will then be seen that large angles of aperture are as useful for balsam-mounted specimens as for others." This statement, *as it stands*, I still hold to; but I must protest against its being considered as "tantamount" to any such absurdity as that into which Mr. Wenham has translated it, which is indeed "contrary to reason." I mean, however, to assert what Mr. Wenham so emphatically denies, viz.: that it *does* make a difference, whether rays are traced *into* a refractive medium or *out* of it. I cannot admit that these two cases "come to precisely the same thing."

Mr. Wenham surely does not need to be told, that if "the trigonometry of optics establishes anything, it proves that the same medium which bends an incident ray *towards* the perpendicular when it enters, will bend it *from* the perpendicular when it emerges. Hence a beam of divergent rays, from a point within a medium, is rendered still more divergent when it emerges, and in fact is spread out, so that the extreme rays which emerge are in the plane of emergence, or make an angle of 180° with each other.

Mr. Wenham seems to confine his attention to the fact, that a large portion of the rays from a balsam-mounted object are lost by internal reflection. This, of course, I never meant to deny; and, in fact, it is one obvious reason why balsam-mounted test objects are, as I long ago stated, far more difficult to resolve than when mounted dry. The loss of a portion of rays in this manner, however, has nothing whatever to do with the present question, which is simply whether, of the rays that do emerge (and which make every angle with each other, from 0° to 180°) more will be collected by a lens of large or small aperture. Certainly Mr. Wenham cannot deny that the larger

aperture will receive the larger number of rays; and if so, then my statement is fully confirmed, that "large angles of aperture are as useful for balsam-mounted objects as for others."

The distinction I have alluded to above, between the intensity of illumination of the balsam-mounted object, and the effect of large angles of aperture is alluded to by Dr. Robinson, of Armagh, in his paper "On measuring the angular aperture of object-glasses," published in the Proceedings of the Royal Irish Academy, January 23, 1854, where he states in a note, that the effect of mounting in balsam is, in fact, equivalent to reducing the aperture of the objective below 100°, *as far as illumination is concerned, though a much larger one may be required to take in the pencil.*—J. W. Bailey, *West Point, New York.*

Mohl on Chlorophyll.—In a recent number of the 'Annals and Magazine of Natural History,' Mr. Henfrey has translated an interesting paper by Mohl on Chlorophyll. This paper thus concludes:—

"Gathering all these points together,—the occurrence of Chlorophyll in cells which contained no starch; the occurrence of membrane-like Chlorophyll-structures, not preceded by any corresponding starch-structure, or accumulations of starch-grains; the growth of Chlorophyll-globules after the starch-grains have vanished from them; the simultaneous increase in size of starch and Chlorophyll-globules in other plants;—we are necessarily led to the conclusion, that Chlorophyll is not produced by the transformation of starch-grains, but that the two structures, though frequently connected together, originate independently of each other. The starch may exist earlier, and the Chlorophyll accumulate around the starch-grains as around a nucleus—as may be seen so clearly in the internal starch-bearing cells of a potato when exposed to the light, and, in extremely numerous cases, in the leaves of buds; and, on the contrary, the starch-grains lying in Chlorophyll-globules may increase in size independently, and even be formed in Chlorophyll which originally contained no starch."

Mr. Henfrey has added the following notes:—

"My own observations fully confirm the statement that starch-grains may originate in Chlorophyll-globules at first totally devoid of starch; I have traced the formation of groups of starch-grains in this way in the interior of Chlorophyll in the Hepaticæ and other Cryptogamous plants. There can be little doubt that the Chlorophyll belongs to the protoplasmic substances of the cell-contents, and is capable of producing starch equally with the colourless protoplasm. From the mode in which starch-grains are formed, both in Chlorophyll and in colourless protoplasmic masses, I am inclined to regard it as a product formed by deposit or secretion on the *inside* of cavities or vacuoles of the latter, by a process analogous to the formation of the cellulose layers on the outside of the primordial utricle. I do not find the protoplasmic nucleus described by Crüger in all starch-grains. This would account for most of the phenomena observed. At

the same time it would afford an argument for those who doubt the distinct existence of a determinate layer or primordial utricle on the outside of the protoplasm. Our author's statements as to the *pellicular* character of the apparent membrane described by Nägeli on starch and Chlorophyll-corpuscles, would seem to apply to some extent to the so-called *primordial utricle*. Pringsheim has recently published some important observations on this head, which I trust to be able shortly to test and report on.

"The observations of Mr. Grundy agree, in some respects, with those I have made in a great variety of cases, but the striæ are certainly not superficial, and I doubt the existence of the outer membrane. I think there is merely a *pellicle* of protoplasm, coagulated on the starch-grain when re-agents are added. This would appear to dip between the constituent grains of groups; in some cases, however, the interposed pellicle becomes obliterated, and the groups, mostly *pairs* in such cases, have the outer layers common over the whole. It seems to me that there is a fallacy in the various accounts of the membrane of the starch-granule, founded on the experiment of boiling starch, assuming, as I do after repeated experiments, that the main body of the structure is that of concentric laminæ of a tough material. If there were an enclosing membrane distinct from the starch-layers, thick enough to bear expanding to many hundred times its original superficial dimensions, this *must* be thick enough when unexpanded to be clearly visible as a well-defined coat. The saccate bodies obtained by boiling really result from the whole softened substance of the granules becoming blown out (like india-rubber bottles) by a process of endosmosis. The internal substance softens and absorbs water more readily than the other—a sufficient cause for the endosmosis. This difference of condition of the layers is proved by an experiment I have repeatedly made with fresh potato-starch. If we attempt to cut it with a knife, it breaks with a roughish fracture, like a lump of partially-hardened clay; if the fragments are placed in *cold* water, the internal part of the starch will often swell and protrude irregularly, while the outer layers retain their shape. I cannot confirm Mr. Grundy's statement, that the "skins" can be boiled until they no longer take the blue (or bluish) colour with starch. Still, since after boiling, as in treatment with sulphuric acid, the colour of the substance with iodine tends more and more to pinkish purple, it is possible that long boiling may change this condition, just as roasting does."

On the Microscopical Structure of the Victoria Regia (Lindl.)— The stomata are nearly circular, formed of two crescentic cells. They are minute, measuring only the 1-960th of an inch in diameter, and so closely placed that one square inch of epidermis will contain 139,843. An ordinary-sized leaf, 4 feet in diameter, with a surface of 1850·08 square inches, will thus contain upwards of twenty-five millions of stomata (25,720,937).

The lower surface of the Victoria leaf is somewhat peculiar. It exhibits no stomata, but is thickly clothed with flexuous hairs, consisting of cylindrical cells, and arising each from a small round basal cell very distinct both from the other cells of the hair and those of the epidermis, which latter are filled with diffused colouring matter, mostly red, but in some blue,

and a few are without colour. These hairs average about the 1-55th part of an inch in length, by the 1-490th of an inch in breadth. There are seen scattered over the surface, in addition to the hairs, numerous round cells, precisely similar to those which form the bases of the hairs; these apparently indicate non-developed hairs. The arrangement of these cells (taking together those which form the basis of hairs and those whose hairs are abortive) is so strikingly similar to the arrangement of the stomata on the opposite surface of the leaf, as to suggest the question whether these cells are not homologous with the stomata; are in fact the cells from which stomata would be evolved if they were produced. This idea is strengthened by the fact that a trace of chlorophyll is seen in these cells, while it is entirely absent in the ordinary epidermal cells, but present in well-defined globules in the cells of the true stomata. Whatever be the homological relationship between the hairs and the stomata, there can be no doubt that the cells to which I have alluded represent undeveloped hairs; and, indeed, Dr. Lankester has long ago shown the tendency to non-development of hairs on aquatic plants, such, for example, as in the case of *Callitriche*, where peculiar rosette-shaped cells in the epidermis represent non-developed hairs.

If a portion of the leaf of the plant be held between the eye and the light, it will be seen that the thinner parts are perforated with numerous minute holes; indeed these are distributed more or less over the whole leaf, excepting those parts occupied by the ribs. The nature of these openings, and their purpose in the economy of the plant, have given rise to some speculation. Hooker describes them thus:—"Conspicuously may be seen the numerous pores or *stomata;* these are circular, generally margined with red, and apparently formed of a thin membrane, surrounded by a circle of red cells," and Fitch's drawing shows a membrane stretched across the pore. This is only the case, however, in the early condition of the leaf; at maturity, the thin pellicle disappears, leaving an actual perforation, measuring in the specimens I examined the 1-84th part of an inch across. The development of these pores has been carefully described by Planchon, who has given them the name of Stomatodes, and subsequently by Trecul. Planchon believes that they are designed to permit the escape of gases which are disengaged from the water, and would otherwise collect in the spaces formed between the ribs and the under-surface of the leaf. It appears to me, however, that they might with equal propriety be regarded as intended to drain off the superfluous water which,

from rain or other sources, might collect upon the surface of the leaf, whose edges, being turned up as a bulwark against the surface ripple of the water, would prevent its speedy escape otherwise; and we well know that such a huge mass of cellular tissue shut out from the air by a covering of water soon dies. But, I believe, neither hypothesis explains the real nature of the so-called stomatodes. It is desirable to understand their homology before we speeulate on their functions. They have none other than a fanciful relationship with stomata. In their own structure they present no characters in common with stomata, nor are they even connected with true stomata; on the contrary, there is an absence of stomata around their margin on the upper surface, the thinning of the tissue at that part rendering such organs unnecessary.

While the perforations may serve both the purposes indicated above, and thus afford an example of the modification of a structure to suit the requirements of a plant, such as we see every day in the organs of animals and plants, I believe that they are merely the simplest form of a reduction of tissues more fully brought out in other plants. We well know the tendency of phanerogamous plants growing in water to lose the soft tissues of their leaves; *Ranunculus aquatilis* is a familiar example wherein the submersed, as well as some of the floating leaves, exhibit only a very partial development of parenchyma; we also know that this reduction of parenchyma is not confined to leaves actually submersed, but is participated in by those which float upon the surface. *Ouvirandra fenestralis* is a striking example, the parenchyma being so much reduced as to give the leaf the appearance of a skeleton leaf. In the *Victoria* it appears to me that the perforations indicate the beginning, as it were, of a reduction of this kind, which if it proceeded far enough would result in a lattice-work leaf like the Ouvirandra, represented only by the strong-ribbed venation with which the Victoria is furnished. In fact, the thinness of the intercostal parts of the leaf, as compared with the ribs, is an equally striking indication of such a reduction. Viewed from this point of view, these pores resolve themselves into a form of development with which we are familiar in other plants, and lose their supposed singularity as a feature of structure peculiar to the *Victoria*.—G. Lawson. *Proceedings of Botanical Society.*

The Stomachs of the Polygastrica.—A spirited controversy exists concerning the internal structure of the so-called Polygastric Infusoria. In England the subject has not met with

so much attention as abroad, where Professor Ehrenberg, of Berlin, and Dr. Pouchet, of Rouen, stand at the head of one party of naturalists; whilst opposed to them is a large number, supporting the views of Dujardin in France, and of Siebold in Germany.

Having had my attention attracted to this dispute, and conversed with many of those naturalists who take an active interest in the controversy (especially with Dr. Pouchet, whose judgment I find in all cases to be the least prejudiced), curiosity has tempted me to scrutinise their theories with care, and practically to test their merits.

Briefly stated, the following are the views espoused by the respective parties of naturalists:—

Ehrenberg states, the digestive apparatus of the Polygastrica (now known as Infusoria) to consist of many globular stomachs. In the higher forms, these stomachs are connected by a bowel, which has a receiving and a discharging orifice, situated on the external integument of the Animalcule; in the lowest types the bowel is dispensed with; a number of stomachs, along with a single orifice, being all that Ehrenberg has been able to discover.

The theories of this great naturalist are fully described in Mr. Pritchard's work.

Dr. Pouchet, who to some extent supports Ehrenberg's opinion, acknowledges the existence of the polygastric structure, so far as the fixed globular stomachs are concerned, but candidly confesses that he has not been able to discover a connecting bowel. He has chiefly studied the *Kolpoda* and *Vorticellæ*.

Opposed to this theory, Dujardin affirms that the so-called Polygastrica contain irregularly-formed alimentary granules, which continually rotate within the body, in the same manner as in the *Chara* in Plants; and that not being fixed, as stated by Ehrenberg, they cannot have a connecting bowel attached to the outer integument.

Dr. Cohn, of Breslau, has accurately described this rotation of granules in *Loxodes bursaria*, and contributed an article on the structure of this Infusorium to Siebold's 'Zeitschrift.'

The following are the results (concisely stated) of my investigation, in connection with this disputed question.

I have traced the growth of *Glaucoma scintillans*, from the *Monas socialis* of Ehrenberg (found amongst the *Chlamidomonas*, or green-dust monads, in rain-water), and have seen gradually developed within it many simple globular stomachs, placed in a tolerably regular line round the body. They do *not* rotate, but are permanently fixed. I have fed them with

indigo; seen them *gradually* become filled with that substance, and afterwards resume their transparent appearance, as the digested matter was ejected in a stream from the posterior orifice of the animalcule. After careful and repeated observations, I feel satisfied that no bowel exists (for a blue line, however faint, would in that case be visible).

This genus is *somewhat* allied to *Kolpoda*, the one investigated by Dr. Pouchet; and I can, therefore, confirm his opinion, with the additional observation, that I have found each stomach to be provided with a little circular aperture for the admission of food.

This does not, however, invalidate the theory of Dujardin; for, after reading Dr. Cohn's account of the rotation in *Loxodes*, I carefully examined *Chelodon aureus*, a similar type, and found his observations to be perfectly applicable to this animalcule, with only one difference, namely, that the granules take two different directions from one side of the body, and meeting at the opposite side, are there lost in the general substance of the body. I have also clearly traced the rotation of granules in *Stentor viridis* (*S. polymorphus*, Ehrenberg).

If these observations be correct, it follows that the two parties before alluded to have examined two different types.

Dr. Pouchet (for Ehrenberg's theory is too sweeping) has studied, and accurately described, the structure of *Kolpoda*, *Vorticella*, &c.; whilst Dujardin, Cohn, and others, have correctly observed *Chelodon*, *Loxodes*, *Nassula*, and that type of Animalculæ.

My investigations were made with a good, clearly-defining microscope, manufactured by Schieck, of Berlin, and with powers varying from 200 to 900 diameters.—JAMES SAMUELSON, *Hull*.

PROCEEDINGS OF SOCIETIES.

MICROSCOPICAL SOCIETY, *March* 28, 1855.

Dr. CARPENTER in the chair.

Geo. Bishop, jun., Esq., was balloted for and duly elected a member of the Society.

The Society then adjourned to a soirée.

April 25, 1855.

Dr. CARPENTER in the chair.

E. G. Lobb, Esq., and J. Le Capellain, Esq., were balloted for, and duly elected members of the Society.

A paper by Mr. Farrants on Mr. Peters' Writing Machine was read (Transactions, vol. iii. p. 55).

A paper by Mr. Furze on the Illumination of Objects by Polarized Light was read (Transactions, vol. iii. p. 63).

The President made some remarks on the Structure of the Animal of the Foraminiferæ.

May 23, 1855.

Dr. CARPENTER in the chair.

Mr. R. Tootal, Esq., W. C. Jones, Esq., C. H. Hingeston, Esq., and Capt. W. Noble, were balloted for, and duly elected members.

Mr. Warington read a paper on a new portable form of microscope.

The President made some observations on Foraminiferæ.

June 25, 1855.

Dr. CARPENTER in the chair.

Rev. Jas. Guillemard, Bournemouth; J. M. Burton, Esq., Lee Park; F. Currey, Esq., Blackheath Park, were balloted for, and duly elected.

The following communications were read.

On three new species of Rotifers, and a microscopic plant, found in India by J. Mitchell, Esq., Bangalore.

On the Circulation in *Anacharis Alsinastrum* by Dr. Branson and Mr. Wenham. (Vol. III. 'Journal of Microscopical Science,' pp. 274–277.)

The President described two low-priced microscopes, which had obtained the prize at the Society of Arts. The instruments were also exhibited. (Vol. III. 'Journal of Microscopical Science,' p. 306.)

October 31, 1855.

Dr. CARPENTER in the chair.

F. H. Glossop, Esq., Spring Grove, Isleworth; W. Heslop, Esq., St. John's-street, and M. Bland, Esq., Fleet-street; were balloted for, and duly elected members of the Society.

A paper by E. G. Lobb, Esq., on *Anacharis Alsinastrum* was read.

The President gave an account of certain proceedings at the British Association.

November 28, 1855.

GEORGE JACKSON, Esq., in the chair.

C. L. Bradley, Esq., Barnsbury Park; E. Grove, Esq., Park-street, Westminster; E. Cobbett, Esq., 4 Cullum-street; Mr. H. Williams, Somerset House; and John White, Esq., Cowes, Isle of Wight, were balloted for, and duly elected.

Mr. Wenham read a paper on the formation and development of Vegetable Cells (Transactions, vol. iv. p. 1).

ROYAL SOCIETY.

Mr. GOSSE, "*On the Structure, Functions, and Homology of the Manducatory Organs in the Class Rotifera.*" March 1, 1855.

IN this paper the author institutes an examination of the manducatory organs in the class Rotifera, in order to show that the various forms which they assume can all be reduced to a common type. He further proposes to inquire what are the real homologues of these organs in the other classes of animals, and what light we can gather, from their structure, on the question of the zoological rank of the Rotifera.

After an investigation of the bibliography of the class from Ehrenberg to the present time, in which the vagueness and inexactitude of our knowledge of these organs is shown, the author takes up, one by one, the various phases which they assume throughout the whole class, commencing with *Brachionus*, in which they appear in the highest state of development. Their form in this genus is therefore taken as the standard of comparison.

The hemispherical bulb, which is so conspicuous in *B. amphiceros*, lying across the breast, and containing organs which work vigorously against each other, has long been recognized as an organ of manducation; it has been called the gizzard, but the author proposes to distinguish it by the term *mastax*. It is a trilobate muscular sac, with walls varying much in thickness, receiving at the anterior extremity the *buccal funnel*, and on the dorsal side giving exit to the *œsophagus*.

Within this sac are placed two geniculate organs (the *mallei*), and a third on which they work (the *incus*). Each *malleus* consists of two parts (the *manubrium* and the *uncus*), united by a hinge-joint. The *manubrium* is a piece of irregular form, consisting of *carinæ* of solid matter, enclosing three areas, which are filled with a more membraneous substance. The *uncus* consists of several slender pieces, more or less parallel, arranged like the teeth of a comb, or like the fingers of a hand.

The *incus* consists of two *rami*, which are articulated by a common base to the extremity of a thin rod (the *fulcrum*), in such a way that they can open and close by proper muscles. The fingers of each *uncus* rest upon the corresponding *ramus*, to which they are attached by an elastic ligament. The *mallei* are moved to and fro by distinct muscles, which the author describes in detail, and by the action of these they approach and recede alternately; the *rami* opening and shutting simultaneously, with a movement derived partly from the action of the *mallei*, and partly from their own proper muscles.

All these organs have great solidity and density; and, from the action of certain menstrua upon them, appear to be of calcareous origin.

The writer proceeds to describe the accessory organs. The ciliated disc has an infundibuliform centre, which commonly merges into a tube before it enters the *mastax*. The particles of food that float in the water, or swimming animalcules, are whirled by the ciliary vortex into this tube, and being carried into the *mastax* are lodged upon the *rami*, between the two *unci*. These conjointly work upon the food, which passes on towards the tips of the *rami*, and enter the *œsophagus*, which opens immediately beneath them.

From this normal condition, the author traces the manducatory organs through various modifications in the genera *Euchlanis*, *Notommata aurita*, *N. clavulata*, *Anuræa*, *N. petromyzon*, *N. lacinulata*, *Furcularia*, *N. gibba*, *Synchæta*, *Polyarthra*, *Diglena*, *Eosphora*, *Albertia*, *F. marina*, *Asplanchna*, *Mastigocerca*, *Monocerca*, and *Scaridium*. Some of these display peculiarities and aberrations highly curious. Notwithstanding the anomalies and variations which occur, however, the same type of structure is seen in all; and the modifications in general may be considered as successive degenerations of the *mallei*, and augmentations of the *incus*.

The form of the manducatory organs, which occurs in *Triarthra*, *Pompholyx*, *Pterodina*, *Œcistes*, *Limnias*, *Melicerta*, *Conochilus*, *Megalotrocha*, *Lacinularia*, and *Tubicolaria*, is next examined. The organs are shown to be essentially the same as in the former type, but somewhat disguised by the excessive dilatation of the *mallei*, and by the soldering of the *unci* and the *rami* together, into two masses, each of which approaches in figure to the quadrant of a sphere.

Attention is then directed to what has been called (but by a misapprehension) the "stirrup-shaped" armature of the genera *Rotifer*, *Philodina*, *Actinurus*, &c. Here, however, the organs are proved to have no essential diversity from the common type; their analogy with those last described being abundantly manifest, though they are still further disguised by the obsolescence of the *manubria*.

Floscularia and *Stephanoceros*, the most elegant, but the most aberrant forms of Rotifera, close the series. The *mastax*, in these genera, is wanting; and in the former genus the *incus* and the *manubria* are reduced to extreme evanescence, though the two-fingered *unci* show in their structure relative position and action, the true analogy of these organs.

Having thus shown that there is but one model of structure, however modified or disguised, in the manducatory organs of the Rotifera, the author proceeds to the question of their homology. He argues on several grounds that they have no true affinity with the gastric teeth of the Crustacea, though he states his conviction that the Rotifera belong to the great Arthropodous division of animals.

It is with the Insecta that the author seeks to ally these minute creatures; and, by a course of argument founded on the peculiarities of structure already detailed, he maintains the following identifications:—that the *mastax* is a true *mouth*; that the *mallei* are *man-*

dibles; the *manubria* possibly representing the *cheeks*, into which they are articulated; that the *rami* of the *incus* are *maxillæ*; and that the *fulcrum* represents the *cardines* soldered together.

While the author maintains the connexion of Rotifera with Insecta, through these organs in their highest development, he suggests their affinity with Polyzoa, by the same organs at the opposite extremity of the scale, since the oval muscular bulbs in *Bowerbankia*, which approach and recede in their action on food, seem to represent the quadriglobular masses of *Limnias* and *Rotifer*, further degenerated.

If this affinity be correctly indicated, the interesting fact is apparent, that the Polyzoa present the point where the two great parallel divisions, Mollusca and Articulata, unite in their course towards the true Polypi.

Mr. Gosse's paper is illustrated by ninety-six figures of entire Rotifera, or of the parts under review, all drawn from the life, and, for the most part, with a power of 560 diameters.

"*Researches on the Foraminifera.—Part I. General Introduction, and Monograph of the Genus* Orbitolites." By William B. Carpenter, M.D., F.R.S., F.G.S., &c. Received May 21, 1855.

The group of *Foraminifera* being one as to the structure and physiology of which our knowledge is confessedly very imperfect, and for the natural classification of which there is consequently no safe basis, the author has undertaken a careful study of some of its chief typical forms, in order to elucidate (so far as may be possible) their history as living beings, and to determine the value of the characters which they present to the systematist. In the present memoir, he details the structure of one of the lowest of these types, *Orbitolites*, with great minuteness; his object having been, not merely to present the *results* of his investigations, but also to exhibit the *method* by which they have been attained; that method essentially consisting in the minute examination and comparison of a *large number* of specimens.

The *Orbitolite* has been chiefly known, until recently, through the abundance of its *fossil* remains in the Eocene beds of the Paris basin; but the author, having been fortunate enough to obtain an extensive series of *recent* specimens, chiefly from the coast of Australia, has applied himself rather to these as his sources of information; especially as the *animals* of some of them have been sufficiently well preserved by immersion in spirits, to permit their characters to be well made out.

As might have been anticipated from our knowledge of their congeners, these animals belong to the *Rhizopodous* type; the soft body consisting of *sarcode*, without digestive cavity or organs of any kind; and being made up of a number of segments, equal and similar to each other, which are arranged in concentric zones round a central nucleus. This body is invested by a calcareous shell, in the substance of which no minute structure can be discerned, but which has the form of the circular disk, marked on the surface by

concentric zones of closed cells, and having minute pores at the margin. Starting from the central nucleus,—which consists of a pear-shaped mass of sarcode, nearly surrounded by a larger mass connected with it by a peduncle,—the development of the Orbitolite may take place either on a *simple*, or upon a *complex* type. In the former (which is indicated by the *circular* or *oval* form of the cells, which show themselves at the surfaces of the disk, and by the *singleness* of the row of marginal pores), each zone consists of but a single layer of segments, connected together by a single annular stolon of sarcode; and the nucleus is connected with the first zone, and each zone with that which surrounds it, by radiating peduncles proceeding from this annulus, which, when issuing from the peripheral zone, will pass outwards through the marginal pores, probably in the form of *pseudopodia*. In the *complex* type, on the other hand (which is indicated by the *narrow* and *straight-sided* form of the superficial cells, and by the *multiplication* of the horizontal rows of marginal pores), the segments of the concentric zones are elongated into vertical columns with imperfect constrictions at intervals; instead of a single annular stolon, there are two, one at either end of these columns, between which, moreover, there are usually other lateral communications; whilst the radiating peduncles, which connect one zone with another, are also multiplied, so as to lie in several planes. Moreover, between each annular stolon and the neighbouring surface of the disk, there is a layer of superficial segments, distinct from the vertical columns, but connected with the annular stolons; these occupy the narrow elongated cells just mentioned, which constitute two *superficial* layers in the disks of this type, between which is the *intermediate* layer occupied by the columnar segments.

These two types seem to be so completely dissimilar, that they could scarcely have been supposed to belong to the same species; but the examination of a large number of specimens shows, that although one is often developed to a considerable size upon the simple type, whilst another commences even from the centre upon the complex type, yet that many individuals which begin life, and form an indefinite number of annuli, upon the simple type, then take on the more complex mode of development.

The author then points out what may be gathered from observation and from deduction respecting the *Nutrition* and mode of *Growth* of these creatures. He shows that the former is probably accomplished, as in other Rhizopods, by the entanglement and drawing in of minute vegetable particles, through the instrumentality of the pseudopodia; and that the addition of new zones probably takes place by the extension of the sarcode through the marginal pores, so as to form a complete annulus, thickened at intervals into segments, and narrowed between these into connecting stolons, the shell being probably produced by the calcification of their outer portions. And this view he supports by the results of the examination of a number of specimens, in which *reparation of injuries* has taken place. Regarding the *Reproduction* of Orbitolites, he is only able to suggest that certain minute spherical masses of sarcode, with which some of the cells are filled, may be *gemmules*; and that other

bodies, enclosed in firm envelopes, which he has more rarely met with, but which seem to break their way out of the superficial cells, may be *ova*. But on this part of the inquiry, nothing save observation of the animals in their living state can give satisfactory results.

The regular type of structure just described is subject to numerous *variations*, into a minute description of which the author next enters; the general results being, that neither the shape nor dimensions of the entire disk, the size of the nucleus or of the cells forming the concentric zones, the surface-markings indicating the shape of the superficial cells, nor the early mode of growth (which, though typically *cyclical*, sometimes approximates to a *spiral*), can serve as distinctive characters of *species;* since, whilst they are all found to present most remarkable differences, these differences, being strictly gradational, can only be considered as distinguishing *individuals*. It thus follows that a very wide *range of variation* exists in this type; so that numerous forms which would be unhesitatingly accounted specifically different, if only *the most divergent examples* were brought into comparison, are found, by the discovery of those *intermediate links* which a large collection can alone supply, to belong to one and the same specific type.

After noticing some curious *monstrosities*, resulting from an unusual out-growth of the central nucleus, the author proceeds to inquire into the *essential character* of the Orbitolite, and its relations to other types of structure. He places it among the very lowest forms of Foraminifera; and considers that it approximates closely to sponges, some of which have skeletons not very unlike the calcareous net-work which intervenes between its fleshy segments. Of the *species* which the genus has been reputed to include, he states that a large proportion really belong to the genus *Orbitoides*, whilst others are but varieties of the ordinary type. This last is the light in which he would regard the *Orbitolites complanata* of the Paris basin; which differs from the fully-developed Orbitolite of the Australian coast in some very peculiar features (marking a less complete evolution), which are occasionally met with among recent forms, and which are sometimes distinctly traditional towards the perfect type.

"*Notes on British Foraminifera.*" By J. Gwyn Jeffreys, Esq., F.R.S. Received June 19, 1855.

Having, during a great many years, directed my attention to the recent Foraminifera which inhabit our own shores, I venture to offer a few observations on this curious group, as Dr. Carpenter, who has favoured the Society with an interesting and valuable memoir on the subject, seems not to have had many opportunities of studying the animals in the recent state.

Rather more than twenty years ago I communicated to the Linnean Society a paper on the subject, containing a diagnosis and figures of all the species. This paper was read and ordered to be printed in the Transactions of that Society; but it was withdrawn by me before publication, in consequence of my being dissatisfied with D'Orbigny's theory (which I had erroneously adopted), that

the animals belonged to the Cephalopoda; and my subsequent observations were confirmed by the theory of Dujardin. I have since placed all my drawings and specimens at the disposal of Mr. Williamson, of Manchester, who has given such good earnest of what he can do in elucidating the natural history of this group, by his papers on *Lagena* and the Foraminiferous mud of the Levant.

The observations which I have made on many hundred recent and living specimens of various species, fully confirm Dr. Carpenter's view as to the simple and homogeneous nature of the animal. His idea of their reproduction by gemmation is also probably correct; although I cannot agree with him in considering the granules which are occasionally found in the cells as ova. These bodies I have frequently noticed, and especially in the *Lagenæ;* but they appeared to constitute the entire mass, and not merely a part of the animal. I am inclined to think they are only desiccated portions of the animal, separated from each other in consequence of the absence of any muscular or nervous structure. It may also be questionable if the term "ova" is rightly applicable to an animal which has no distinct organs of any kind. Possibly the fry may pass through a metamorphosis, as in the case of the Medusa.

Most of the Foraminifera are free, or only adhere by their pseudopodia to foreign substances. Such are the *Lagena* of Walker, *Nodosaria, Vorticilais* and *Textularia*, and the *Miliola* of Lamack. The latter has some, although a very limited, power of locomotion; which is effected by exserting its pseudopodia to their full length, attaching itself by them to a piece of seaweed, and then contracting them like india-rubber, so as to draw the shell along with them. Some of the acephalous mollusks do the same by means of their byssus. This mode of progression is, however, exceedingly slow; and I have never seen, in the course of twenty-four hours, a longer journey than a quarter of an inch accomplished by a *Miliola*, so that, in comparison with it, a snail travels at a railroad pace.

Some are fixed or sessile, but not cemented at their base like the testaceous annelids. The only mode of attachment appears to be a thin film of sarcose. The *Lobotula* of Fleming, and the *Rosalia* and *Planorbulina* of D'Orbigny belong to this division.

Dr. Carpenter considers the Foraminifera to be phytophagous, in consequence of his having detected in some specimens, by the aid of the microscope, fragments of *Diatomaceæ* and other simple forms of vegetable life. But as I have dredged them alive at a depth of 108 fathoms (which is far below the Laminarian zone), and they are extremely abundant at from 40 to 70 fathoms, ten miles from land and beyond the range of any seaweed, it may be assumed without much difficulty, that many, if not most of them, are zoophagous, and prey on microscopic animals, perhaps even of a simpler form and structure than themselves. They are in their turn the food of mollusca, and appear to be especially relished by *Dentalium Entale.*

With respect to Dr. Carpenter's idea that they are allied to sponges, I may remark that *Polystomella crispa* (an elegant and not uncommon species) has its periphery set round at each segment with siliceous spicula, like the rowels of a spur. But as there is only one

terminal cell, which is connected with all the others in the interior by one or more openings for the pseudopodia, the analogy is not complete, this being a solitary, and the sponge a compound or aggregate animal.

I believe the geographical range or distribution of species in this group to be regulated by the same laws as in the Mollusks and other marine animals. In the gulf of Genoa I have found (as might have been expected) species identical with those of our Hebridean coast, and *vice versâ*.

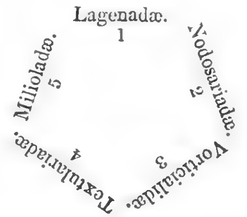
In common with Dr. Carpenter, I cannot help deploring the excessive multiplication of species in the present day, and I would include in this regret the unnecessary formation of genera. Another Linnæus is sadly wanted to correct this pernicious habit, both at home and abroad.

The group now under consideration exhibits a great tendency to variation of form, some of the combinations (especially in the case of *Marginulina*) being as complicated and various as a Chinese puzzle. It is, I believe, undeniable, that the variability of form is in an inverse ratio to the development of animals in the scale of Nature.

Having examined thousands (I may say myriads) of these elegant organisms, I am induced to suggest the following arrangement:—

1. *Lagena* (Walker) and *Entosolenia* (Williamson).
2. *Nodosaria* and *Marginulina* (D'Orb.), &c.
3. *Vorticialis* (D'Orb.), *Rotalia* (Lam.), *Lobatula* (Flem.), *Globigerina* (D'Orb.), &c.
4. *Textularia* (Defrance), *Uvigerina* (D'Orb.), &c.
5. *Miliola* (Lam.), *Biloculina* (D'Orb.), &c.

This division must, however, be modified by a more extended and cosmopolitan view of the subject, as I only profess to treat of the British species. To illustrate MacLeay's theory of a quinary and circular arrangement, the case may be put thus.



The first family is connected by the typical genus *Lagena* with the second, and by *Entosolina* with the fifth; the second is united with the third through *Marginulina;* the third with the fourth through *Globigerina;* and the fourth with the last through *Uvigerina*.

Whether these singular and little-known animals are Rhizopodes, or belong to the Amœba, remains yet to be satisfactorily made out.

London, June 18, 1855.

ZOOPHYTOLOGY.

The species of Polyzoa here described, and most of which appear to be new, occurred on shells from Mazatlan, on the Gulf of California; and for the opportunity of examining them, I have been indebted to the kindness of Mr. Phillip Carpenter, who has prepared a descriptive catalogue of the "Mazatlan Mollusca," for the British Museum. The typical specimens of the forms here noticed, will be found in that Institution.

Order. Polyzoa infundibulata.

Sub-order I. Cheilostomata.

Fam. Membraniporidæ.

Gen. 1. *Membranipora*, Blainv.

1. *M. denticulata* (n. sp.), Busk. Pl. VII., figs. 1 and 2.

Area of cells rhomboidal; internal margin of the aperture denticulate; cells separated by a narrow raised line.

Hab. Mazatlan: on the shells of *Imperator olivaceus*, *I. unguis*, and *Anomia*.

The outline of the cells is usually distinctly defined by a narrow brown line. One or two rounded or triangular eminences (probably ovicells) are visible on many of the cells in front and below. The form bears considerable resemblance to *M. Savartii*, (Savigny, Egypt, pl. 10; *M. Lacroixii*, Savigny, B. M. Cat., p. 60, Plate 104, fig. 1,) but differs from it in several important respects; among which may be noticed a narrow brown line surrounding the cells, and clearly defining one from the other; and the irregularly shaped branching denticles with which the margin of the internal aperture is furnished.

2. *M. gothica*, n. sp., Rylands, MS. Pl. VII., fig. 5, 6, 7.

Area of cells elongated, oval; margin thin and smooth; mouth raised, suborbicular, with an ovide notch inferiorly; the anterior, calcareous, depressed surface of the cells punctated, and perforated on each side by a wide aperture; large, immersed avicularia scattered irregularly over the polyzoary.

Hab. Mazatlan: on *Imperator olivaceus* and *unguis*.

There is occasionally a short blunt spine or process on each side of the mouth, a character which is also presented in *M. Rozieri*, Savig. (B. M. Cat., p. 59, Plate 65, fig. 6) a species to which the present exhibits, in other respects, considerable resemblance, and especially in the existence of the large opening on each side of the front of the cells immediately below the mouth. The differences between the two, however, are sufficiently striking. In *M. Rozieri* the ovicell

is large, superior, rounded, and carinate in front, whilst in *M. gothica*, as in *M. calpensis*, Busk. B. M. Cat., p. 60, Plate 104, fig. 5, 6, this organ appears to be represented by one or two rounded eminences at the bottom of the cell in front. The large scattered avicularia also are characteristic of the present form, as well as its far larger size.

The same species occurs on a Pearl-oyster shell, for which I am indebted to Dr. J. E. Gray, the habitat of which seems to be doubtful. In M. Milne Edward's Memoir "Sur les Eschares," p. 17, Plate 12, fig. 13, a miocene fossil is described and figured, which bears some resemblance to the present; it differs principally, so far as can be determined from the figure alone, in the thickened and granulated margin of the area.

3. *M.*   , n. sp.? Pl. VII., fig. 3, 4.

Apparently an undescribed form, but requiring further research for its precise determination.

Hab. As the preceding.

Gen. 2. *Lepralia*, Johnston.

1. *L. marginipora*, Reuss. Fossil. Polyp. d. Wiener tertiar. Becken., p. 88. Pl. 10., fig. 23. Busk, l. c., p. 4.

Cells ovate, convex or slightly depressed, immersed, roughish, punctate at the margin; mouth round, or subelliptical; margin thickened, with an avicularium on each side.

Hab. Mazatlan: on *Imperator unguis*; Vienna tertiary basin (fossil)?

As the form appears precisely to resemble the tertiary species described and figured by Reuss, I have applied his name to it, and in great part employed his character.

2. *L. humilis*, n. sp. Busk, l. c., p. 5. Pl. VIII., fig. 1.

Cells immersed, depressed, or flattened, surface obscurely punctate; mouth small, rounded, with a shallow sinus in the lower lip, margin simple, thin.

Hab. Mazatlan: on *Imperator unguis.*

3. *L. hippocrepis*, n. sp. Busk, l. c., p. 4. Pl. VIII., fig. 2.

Cells immersed, punctate; mouth suborbicular or elliptical, its upper margin in the older cells inconspicuous, inferiorly and laterally, thickened with an avicularium on each side.

Hab. Mazatlan: on *Imperator olivaceus.*

The peculiar horse-shoe shaped mouth of the older cells, with the avicularia on either side, sufficiently distinguishes the present from *L. marginipora*, to which, in the mouth of the younger cells, it bears some resemblance.

4. *L. Mazatlanica*, n. sp. Busk, l. c., p. 3. Pl. VIII., fig. 4.

Cells immersed, depressed, or ventricose; surface punctate; mouth

suborbicular, with a wide sinus in the lower lip; margin thickened, raised; a single avicularium (more rarely two) on the side near the mouth.

Hab. Mazatlan: on *Imp. olivaceus* and *unguis.*

This form might easily be confounded with some varieties of *L. unicornis*, or *L. Ballii* (B. M. Cat.) It is distinguished, however, by its reddish colour, and the raised mouth, together with its thickened margin. The single, or sometimes double *avicularium*, points outwards and upwards, and the mandible is prolonged and acute. This organ is sometimes, but not often absent.

5. *L. adpressa*, Busk. (B. M. Cat., p. 82. Pl. CII., fig. 3, 4.)

Hab. Mazatlan: on *Columbella major*, *C. fuscata*, and *Pisania gemmata*, not uncommon. Chiloe, 96, fm. Shell; Darwin.

The Mazatlan form differs from that from which the former description and figure were taken, in the absence, or indistinctness rather, of the radiating grooves. In other respects the two agree very closely.

6. *L. atrofusca*, Rylands, MS.

Cells elongated, ovate or rhomboidal, bordered with a thin elevated line, surface punctate; mouth suborbicular, sinuated in the lower lip, toothed on each side.

Hab. Mazatlan: on *Imper. olivaceus* and *unguis*, and on *Anomia.*

General hue blackish; and even when the cells are more calcareous, and on that account whiter, the dark interstitial line remains very evident. It is quite distinct from *L. cucullata* (B. M. Cat., p. 81, Plate 96, fig. 4, 5) which is also of a black colour, and occurs in the Mediterranean.

7. *L. trispinosa*, Johnston. (B. M. Cat., p. 70. Pl. 85, fig. 1, 2. Pl. 57, fig. 7.)

Hab. Mazatlan: on Imperator? Britain.

A single minute specimen only occurred, but this is quite undistinguishable from the British form.

8. *L. rostrata*, n. sp. Busk, l. c., p. 4.

Cells immersed, surface tuberculous or granulous; mouth immersed, upper margin inconspicuous; lower lip deeply grooved, armed with a large sessile avicularium,

Hab. Mazatlan: on *Imp. unguis.*

The lower margin of the mouth, in the mature cells, is deeply grooved in the middle; and on one side of the groove is a strong, short, blunt spinous process; and on the other a comparatively large, raised avicularium, which looks towards the sulcus, and whose mandible is acute, and points upwards and outwards. The surface of the cell is often beset with short raised spines or processes; and these projecting over the

mouth of the cell beneath, give it the appearance of being furnished with several oval spines.

Gen. 3. *Cellepora*, O. Fabricius.

1. *C. papillæformis*, n. sp., Busk, l. c., p. 5. Pl. VIII., fig. 5.

Cells sub-hexagonal, raised, surface punctate; mouth suborbicular, with a tooth on each side, margin simple, thin; scattered avicularia, with a triangular mandible.

Hab. Mazatlan: on *Imp. olivaceus.*

A well-marked and distinct form belonging to that subdivision of Cellepora in which the mouth is not armed with a projecting avicularium. The top of each cell projects in the form of a rounded mamillary eminence from a hexagonal area, which defines the border of the cell. The cells are of very unequal size, and very irregularly disposed. It is of a brownish colour.

2. *C. cyclostoma*, n. sp., Busk, l. c., p. 5. Pl. VIII., fig. 3. *a, b, c.*

Cells suberect or decumbent, discrete; surface punctate; mouth large, rounded above, with a wide sinus in the lower lip; the margin in the older cells much raised, thickened, occasionally dilated, infundibuliform, and furnished with a minute avicularium on each side.

Hab. Mazatlan: on *Imp. unguis.*

The wide, rounded, or elliptical, raised margin of the mouths of the distant cells, gives the polyzoarium of the present species a very peculiar and well-marked aspect. It is of a brownish hue or white.

Sub-order II. CYCLOSTOMATA.

Fam. DISCOPORADÆ, Busk, MS.

Gen. Defrancia, Brown.

1. *D. intricata*, n. s., Busk, l. c., p. 6.

Disc very irregular in form, rows of cells radiating irregularly; orifices of cells and intersticial pores of equal size.

Hab. Mazatlan: on *Imperator unguis.*

The small irregular patches appear to be constituted by the confluence of several sets of *costæ*, with their corresponding interstices, each set radiating from a depressed central point. It differs from *D. deformis*, Reuss (op. cit. p. 36, Plate 5, fig. 24), in the uniform size of the openings of the tubes in the costæ, and of the pores in the interstices.

Besides the above, there occur on some of the shells in the same collection, indications of other species, but in too imperfect a condition to allow of their determination with any certainty. Among these, perhaps the best marked are a species strongly resembling *Cellepora pumicosa*, Linn., a species of *Lepralia*, and a *Tubulipora.*

ZOOPHYTOLOGY.

DESCRIPTION OF FIGURES.

Plate VII.

Fig.

1, 2.—*Membranipora denticulata.*

3, 4.—*Membranipora sp.?*

5, 6, 7.—*M. gothica.*

8.—*Lepralia marginipora.*

Plate VIII.

1.—*Lepralia humilis.*

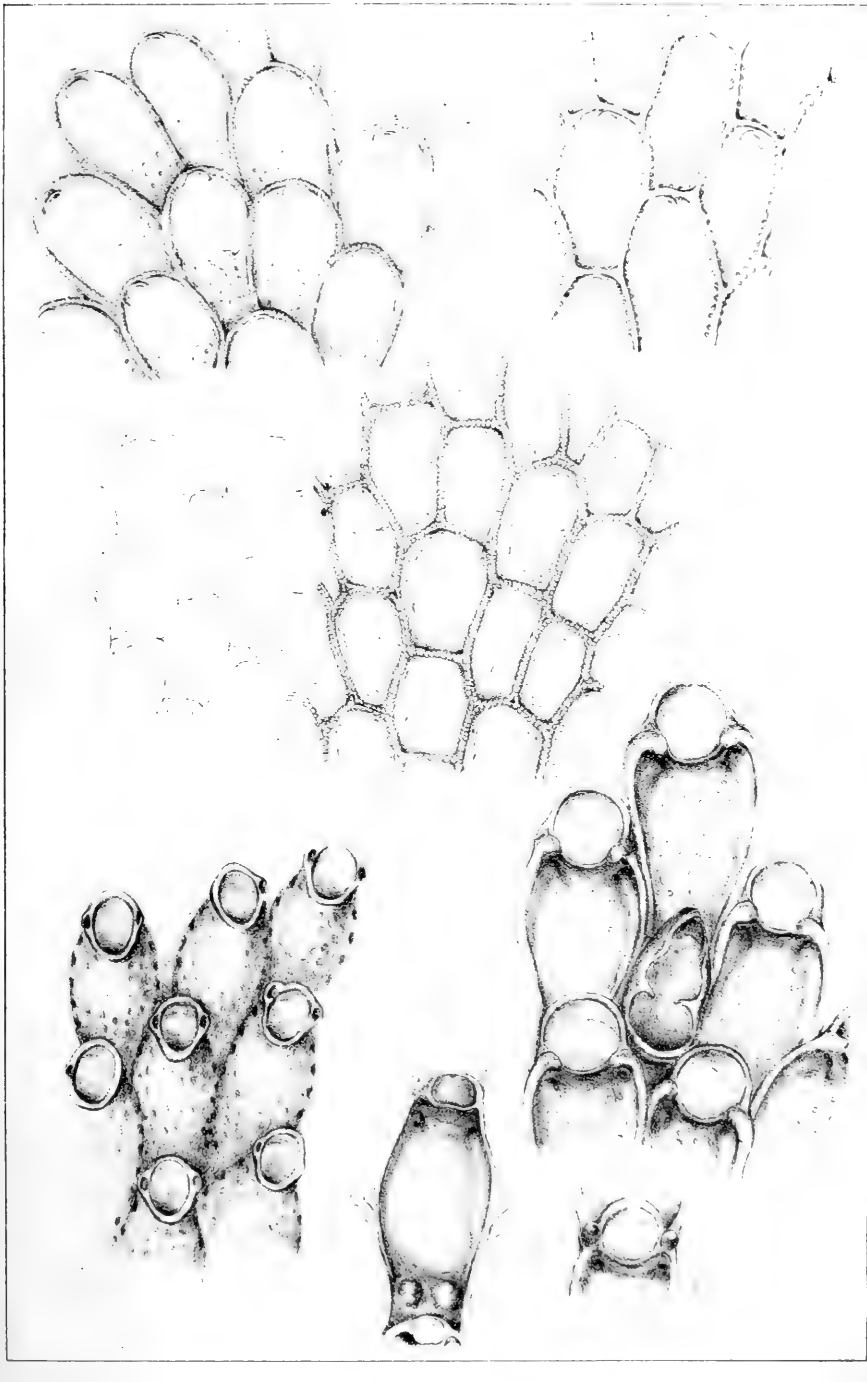
2.—*L. hippocrepis.*

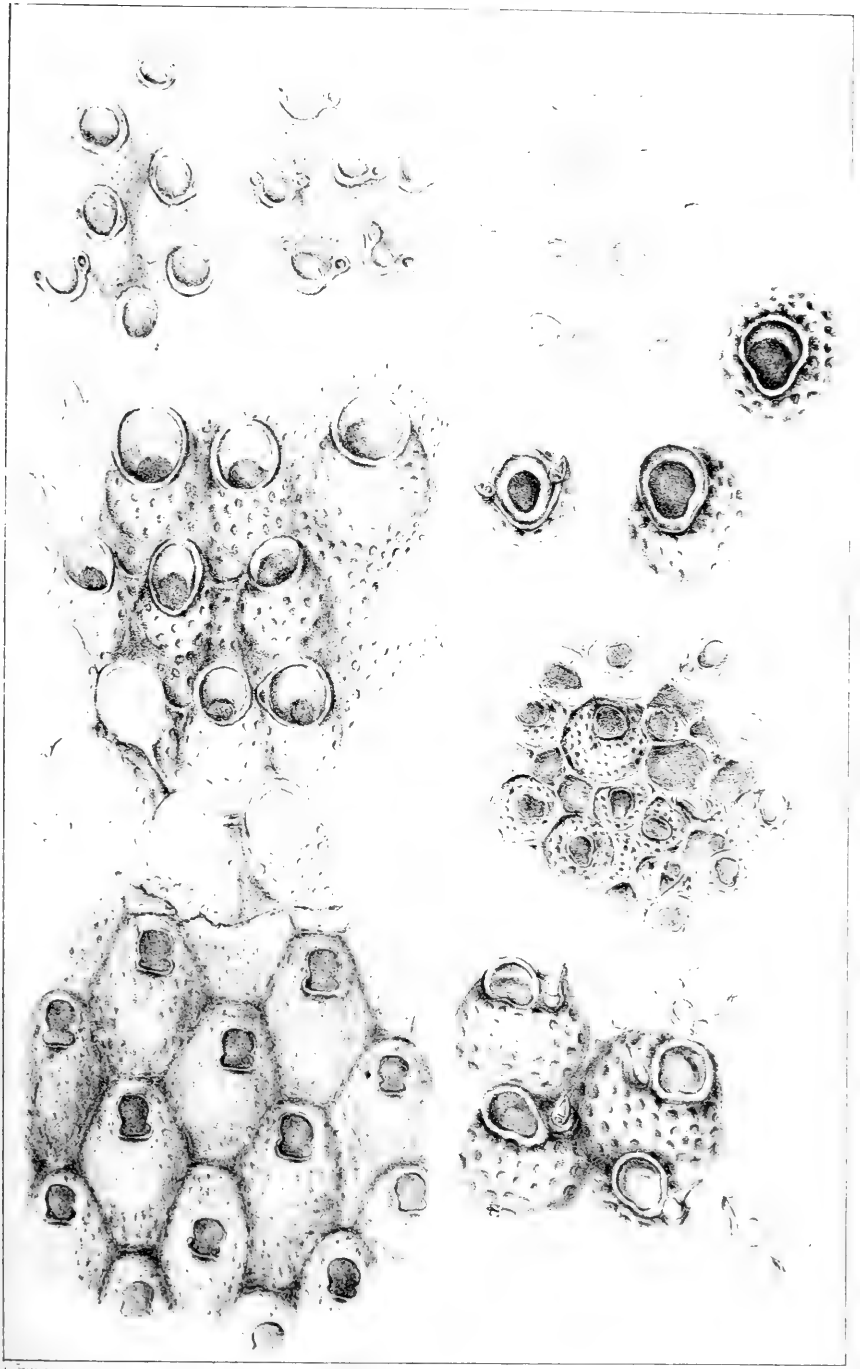
3.—*Cellepora cyclostoma.*

4.—*L. Mazatlanica.*

5.—*Cellepora papillæformis.*

6.—*L. adpressa.*





DESCRIPTION OF PLATE III.,

Illustrating Pringsheim's paper on the Impregnatiou and Germination of Algæ.

Fig.

Figs. 1 to 20, *Vaucheria sessilis*, multiplied 250 diameters.

1 to 4.—Stages of development of the sexual organs before impregnation.

5.—The sexual organs during impregnation.

6 to 8.—The way in which the female organ (the so-termed "spore") opens, the "cutaneous layer" bursts through, and a portion is constricted off.

9.—Approach of the spermatozoids to the female organ before the formation of the membrane of the embryo-cell (the true spore).

10.—The point of the female sexual organ *after* the formation of the membrane of the true spore.

11, 12.—Later condition of the spore, after impregnation.

13 to 16.—Later condition of the male and female organs after impregnation. They show the subsequent *slow* detachment of the membrane of the male organ (the *antheridium* formed out of the summit of the "hornlet"), and the *gradual decoloration* of the contents of the spore, lying in the female sexual organ (the *sporangium*).

17.—Colourless spore after it has become detached from the parent tube.

18.—A spore detached from the tube, which after long rest (three months) has again become green ; an indication of its awakening development.

19, 20.—Germination of the viridescent spores.

Figs. 21 to 24, *Fucus vesiculosus*, multiplied 200 diameters.

21.—Large spore (*sporangium*), whose contents the eight still connected "division spores" have escaped.

22.—"Division spores," isolated before impregnation ; the clear central spot shows the true cell-cavity filled merely with fluid.

23.—Division spore *after* impregnation. The spermatozoids may be seen *within* the membrane.

24.—Earlier state of germination of an impregnated "division spore."

Fig. 25, *Sphacelaria tribuloides*, multiplied 300 diameters.

25.—Propagative gemmule, whose terminal cell transformed into a *Sphacela* contains an *antheridium* partly emptied and partly filled with spermatozoids.

Figs. 26, 27, *Œdogonium tumidulum*, multiplied 350 diameters.

26, 27.—*Sporangium during* (fig. 26) and *after* (fig. 27) the formation of the micropyle for the spermatozoids.

Figs. 28 to 34, *Bulbochæte*, multiplied 250 diameters.

28.—Sporangium of *Bulbochæte setigera* ; the passage into the interior of the *sporangium* is already formed by a transverse fissure of the membrane. A *microgonidium* has germinated upon the *sporangium*, and discharged its contents.

29.—A similar condition in a *sporangium* of *B. crassia* (n. sp.)

30, 31.—Sporangia of *B. intermedia*, ruptured in consequence of the incipient development of the *spore*. The spore, covered only by the innermost layer of the cell-wall, has escaped from the *sporangium*.

32.—The liberated spore is somewhat elongated, and

33.—Its contents divided into four portions.

34.—The division is completed ; the four reddish green zoospores, produced from the contents of the quiescent spore, are already fully formed.

DESCRIPTION OF PLATE VI.,

Illustrating Mr. Tomes's paper on Dental Tissues.

Fig.

1.—A section from a temporary tooth, in which the dentine (*a*) and the enamel (*b*) have been removed by absorption, leaving the festooned outline (*c*).

2.—A section from the fang of a tooth, in which the dentine (*a*) has been removed, together with the cementum (*c*), and again made good by the deposition of cementum. The appearance presented at the junction of the dentine and cementum, where absorption has not encroached upon the tissues at that point, is shown at (*b*). The curved irregular lines in the cementum indicate the extent of absorption at various periods, and the boundaries of the tissue which has replaced the lost parts.

3.—A section from a temporary tooth, the fangs of which have been absorbed, and the crown hollowed out; the enamel having been partly removed, and both tissues coated over with new cementum. (*a*), the dentine; (*b*), the enamel; (*c*), the cementum; (*d*), the junction of the absorbed surface of the enamel and new cementum.

4.—A section of enamel, in which the centre (*a*) has been ground through; (*b*), the enamel fibres, with their granular cells shown faintly; (*c c*), the sheaths of the enamel fibres.

5.—A more highly magnified view from the same specimen, showing the sheaths of the enamel fibres and their contents.

6.—A transverse section of enamel, showing the sheaths of the fibres with the contents removed.

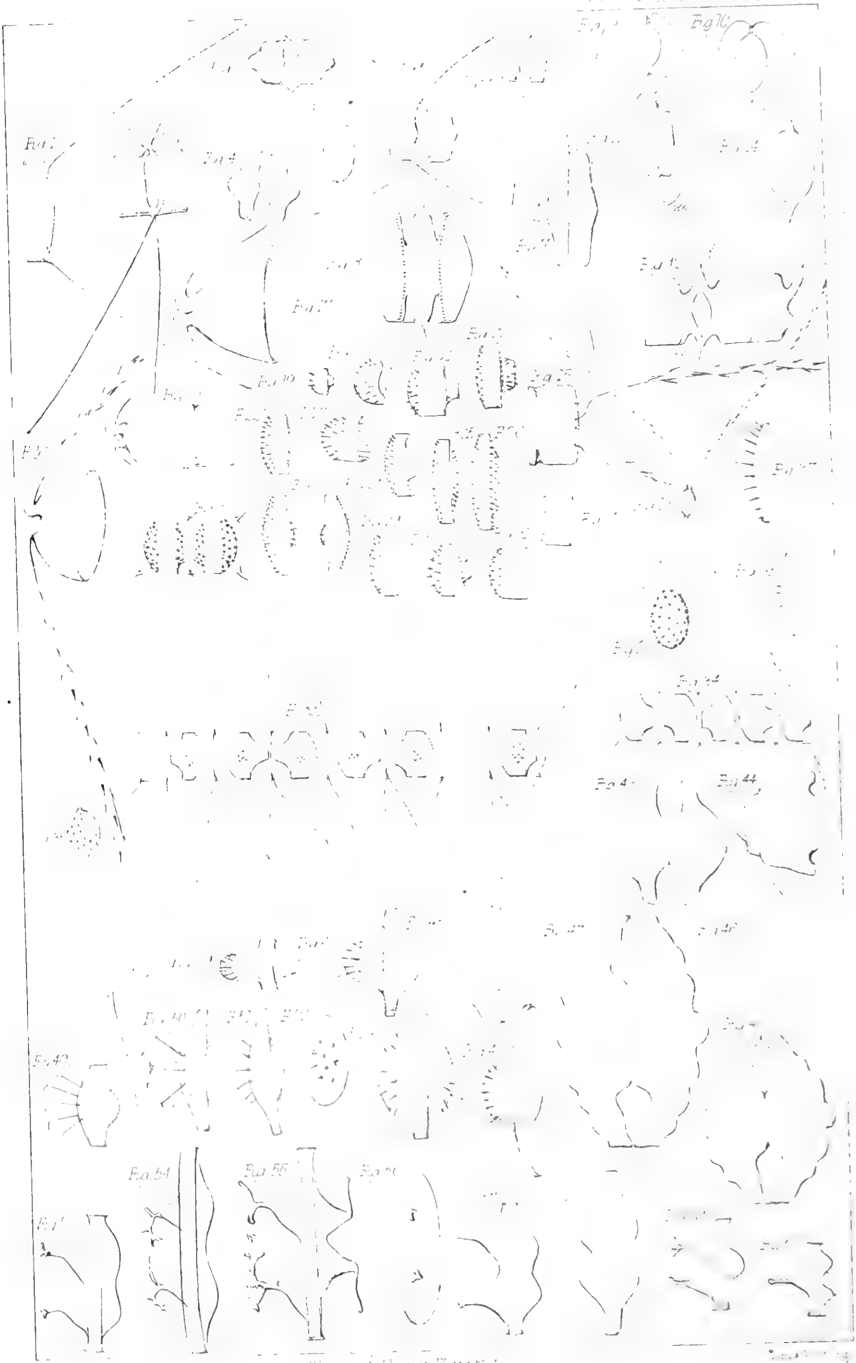


Fig. 10
Fig. 44
Fig. 49
Fig. 54
Fig. 55

DESCRIPTION OF PLATE VII.,

Illustrating Mr. Brightwell's paper on Chætoceros, and some allied forms.

Fig.

1 and 2.—*C. Bacillaria?* Bailey.

3 to 7.—*C. didymum*, Ehr. 5*, side view.

8.—*C. gastridium*, Ehr.

9 to 11.—*C. incurvum*, Bailey. 11, Dr. Bailey's figure reduced, equal 200 diam.

12 to 15.—*C. boreale*, Bailey. 12 to 14 are copied from Dr. Bailey's figures. 13, side view, red, equal 100. 15, from our own specimens in all of which a slight constriction is visible near the inner margin of the frustule; the horns run straight out at a right angle to the frustule.

16 to 18.—*C. Peruvianum* (n. sp.).

19 to 36.—*C. Wighamii* (n. sp.) 19 to 27 represent varieties in form and character of processes of the contained goniothecium-like frustules, from widely distant localities. 29 and 30 show the neck separating. 30, the cup-shaped portion without the neck, equal *Omphalotheca hispida*, Ehr. 32, side view. 33, a filament in its recent state drawn, in water with the Endochrome. 34, short filament with internal frustules irregularly placed. 35, side view of entire frustule. 36, cingulum and horns without the frustule.

37.—*C. hispidum*, Ehr.

38.—*C. navicula*, Ehr.

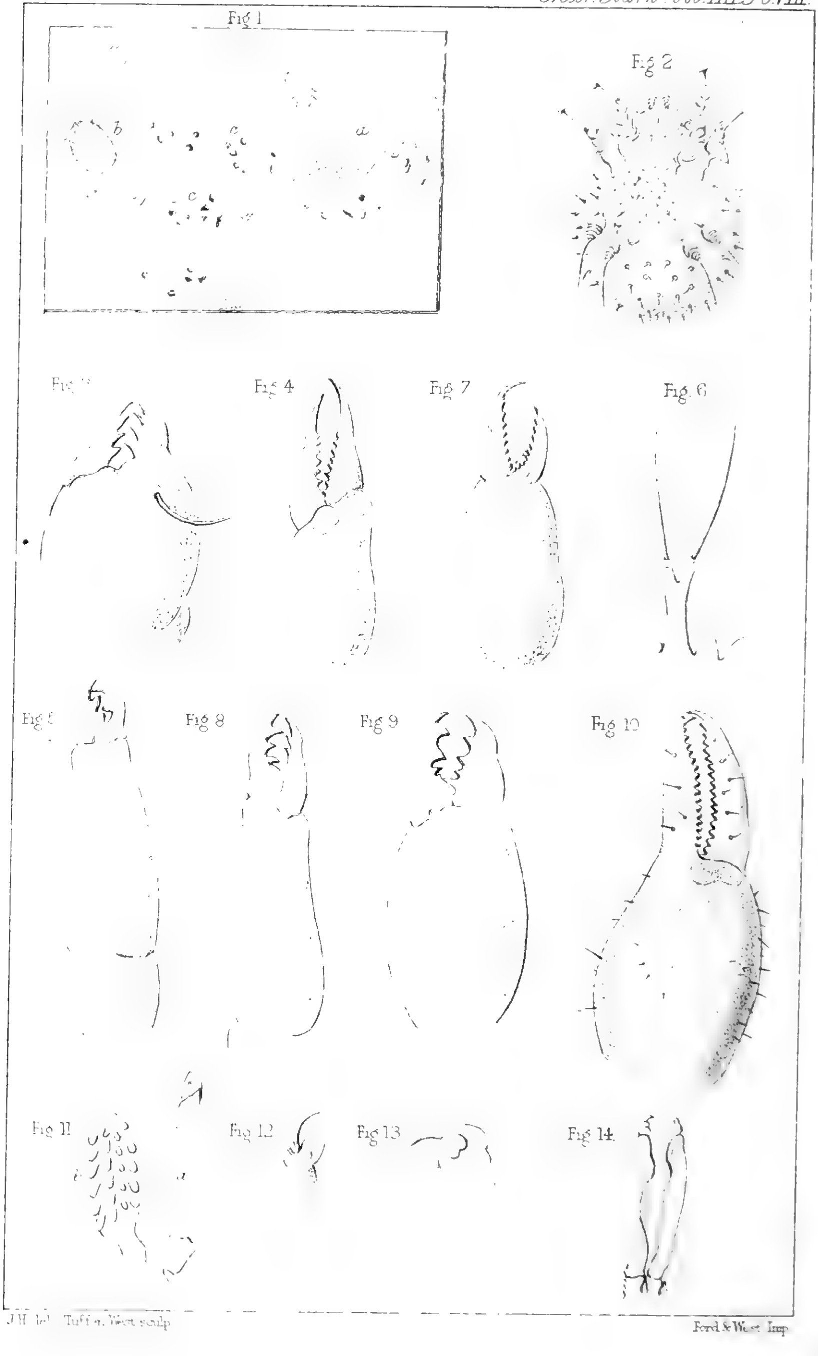
39 to 42.—*C. barbatum?* Ehr.

43 to 46.—*Goniothecium Rogersii*, Ehr. 46, side view.

47 and 48.—*G. Odontella*, Ehr.

49 to 52.—*Syndendrium diadema*, Ehr. 52, side view.

53 to 60.—*Diocladia Capreolus* in different stages of growth. 54, shows the membrane, not unfrequently found adhering to the horns. 56, a side view. 58, frustules like this have probably given origin to Ehrenberg's *Goniothecium didymum*. 59, 60, varieties.



J.H. del. Tuffen West sculp

Ford & West Imp

DESCRIPTION OF PLATE VIII.,

Illustrating Mr. Hepworth's paper on the Mandibles of Acaridæ.

Fig.

1.—A portion of human skin, including an itch pustule; 48 diameters.
 a, ova of *Acarus Scabiei.*
 b, young insects.
 c, effete matter deposited by insects.

2.—Full-grown insect, *Acarus Scabiei;* 65 diameters.

3.—Mandible of ditto; 390 diameters.

4.— „ of *Acarus Sacchari* (female); 390 diameters.

5.— „ of „ (male); 390 diameters.

6.— „ of Acarus of domestic Fly; 630 diameters.

7.*— „ of Long-legged Spider; 30 diameters.

8.— „ of Acarus of Blue Beetle and Humble Bee.

9.†— „ of Cheese Mite; 390 diameters.

10.— „ of *Chelifer cancroides;* 65 diameters.

11*a*.— „ of parasite of Mole; 240 diameters.
 b, proboscis; 240 diameters.

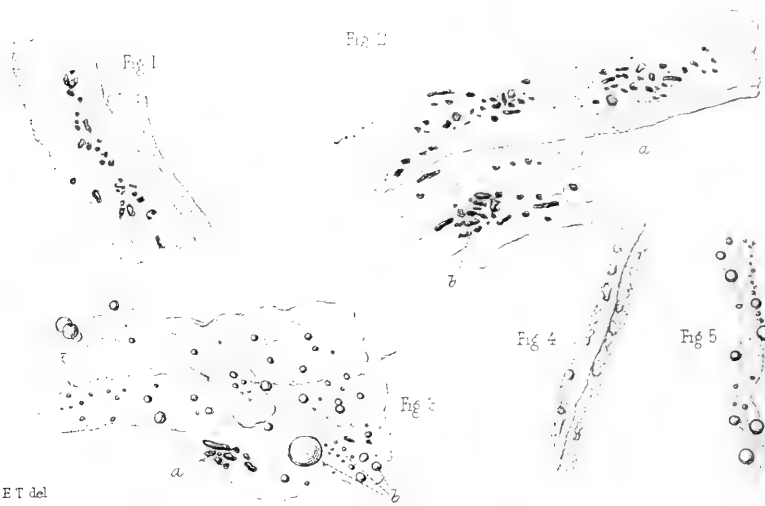
12.— „ of another parasite of Mole; 240 diameters.

13.— „ of parasite of Rabbit; 240 diameters.

14.—Mandibles of parasite of Water Rat; 200 diameters.

* Perhaps, instead of calling these mandibles, they would more properly come under the term maxillary palpi; as in the Scorpion. It appears to be one of the non-spinning Arachnidans. If a leg get accidentally torn off, there is a spasmodic twitching, which continues some seconds in the severed limb. This is so familiar a phenomenon that there will be little difficulty in recognising the kind of spider I mean. As I am an inquirer, I shall be glad to see any remarks on the subject.

† Rymer Jones says (R. J.'s 'Animal Kingdom,' p. 308), in speaking of the *Acaridæ*, "The mouth seems adapted for suction, and the jaws form a piercing instrument, barbed at the extremity." *Note.*—I have not been able to detect this piercing instrument: it has two powerful mandibles, as seen above, and equally powerful maxillæ; and in action they indicate too much motion, and which is of a different character to that where suction is accomplished. How could a flour mite (which has precisely the same kind of apparatus) subsist on dry flour, if it had organs adapted to suction only? I can easily conceive how the parasite of the Mole (fig. 11), with its barbed proboscis, could live by suction.



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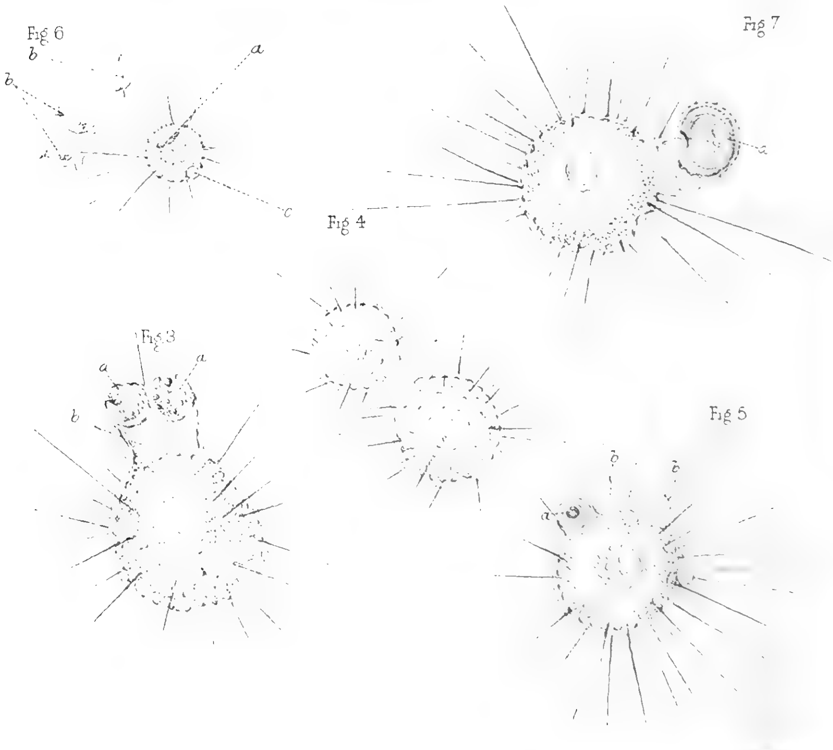


J W del. Tuffen West sculp.

& West imp.

DESCRIPTION OF PLATE IX.,

Illustrating Dr. Thudichum's paper on Green Pigment Degeneration of Muscle.

Fig.

1.—Piece of degenerated muscular fibre from wall of left ventricle. Transverse striæ interrupted by longitudinal lines. Granular green pigment scattered along the axis of the fibre.

2.—Pieces of fibre with longitudinal lines (the striæ have disappeared); *a*, nucleus, and pigment deposits at both ends of the nucleus; *b*, patch of pigment corpuscles, found at equal distances along a fibre.

3.—Pieces of fibre, much macerated, from the right ventricle. Transverse striæ little indurated. Exhibits the striking difference of true fat (*b*) from pigment (*a*).

4.—Nerve fibril from right septum.

5.—The same after boiling with ether and cooling. The cylinder axis (serrated) has disappeared, and fat globules are deposited against the outer membrane of the fibril.

Illustrating Mr. Weston's paper on Actinophrys Sol.

Fig.

3.—*Actinophrys Sol* drawn by Camera lucida; *a a*, two Vorticellæ enclosed in a vesicle; *b*, vesicle.

4.—*A. Sol* in the act of self-division.

5.—*A. Sol*; *a*, an animalcule; *b b*, two expanded cells.

6.—Actinophrys; *a*, *Chætonotus larus* engulphed; *b b b*, three Rotifers caught; *c*, the valve.

7.—*A. Sol* seizing a Vorticella; *a*, Vorticella.

ORIGINAL COMMUNICATIONS.

Further OBSERVATIONS *on the* STRUCTURE *of* APPENDICULARIA FLABELLUM (Chamisso). By T. H. HUXLEY, F.R.S. (Plate X.)

IN a paper read before the Royal Society in 1851, I gave an account of a very singular animal which had been frequently observed and described under various names, as *Appendicularia* (Chamisso), *Oikopleura* (Mertens), *Fritillaria* (Quoy and Gaimard), *Vexillaria* (J. Müller), and *Eurycercus* (Busch), but whose precise place in the animal kingdom was still a matter of doubt. The essential points in that account will be found in the following extracts :—*

*　　　　*　　　　*　　　　*

"The animal has an ovoid or flask-like body one-sixth to one-fourth of an inch in length, to which is attached a long curved lanceolate appendage or tail, by whose powerful vibratory motions it is rapidly propelled through the water."

"The smaller extremity of the animal is perforated by a wide aperture (*d*) which leads into a chamber, which occupies the greater part of the body, and at the bottom of this chamber is the mouth. The chamber answers to the respiratory cavity of the *Tunicata*, and is lined by an inner tunic distinct from the outer; the space between these, as in the *Salpæ*, being occupied by the sinus system.

"On the side to which the caudal appendage is attached, an endostyle (*c*), altogether similar to that of the *Salpæ*, lies between the inner and outer tunics; and opposite to this, or on the ventral side, close to the respiratory aperture, there is a nervous ganglion, to which is attached a very distinct spherical auditory sac, containing a single, also spherical, otolithe. The sac is about 1-200th of an inch in diameter. The otolithe about 1-800th, figs. 1, 2, 4 *a*.

"Anteriorly, a nerve is given off from the ganglion (*a*) which becomes lost about the parietes of the respiratory aperture; another large trunk passes backwards (*b*) over the left side of the œsophagus, and between the lobes of the stomach, until it reaches the appendage, along the axis of which it runs, giving off filaments in its course, fig. 2."

"There is no proper branchia; but that organ seems to be represented by a richly-ciliated band or fold (*e*) of the inner tunic, which extends from the opening of the mouth forwards, along the ventral surface of the respiratory cavity, to nearly as far as the ganglion; when it divides into two branches, one of which passes up on each side, so as to encircle the cavity (*f*). This circlet evidently represents the 'ciliated band' of *Salpa*.

"The mouth (*g*) is wide, and situated at the posterior part of the ventral parietes of the respiratory chamber. The œsophagus (*h*) short, and slightly curved, opens into a wide stomach (*i*) curved transversely, so as to present two lobes posteriorly.

* Nova Acta Acad. Curiosorum, t. xi. pars secunda, pp. 313 and 314.

"Between the two lobes, posteriorly, the intestine (*k*) commences, and passing upwards (or forwards) terminates on the dorsal surface just in front of the insertion of the caudal appendage (*l*).

"The heart lies behind, between the lobes of the stomach. I saw no corpuscles, and the incessant jerking motion of the attached end of the caudal appendage rendered it very difficult to make quite sure even of the heart's existence."

"The caudal appendage (A) is attached or rather inserted into the body on the dorsal surface just behind the anus. It consists of a long, apparently structureless, transparent, central axis (*m*), rounded at the attached, and pointed at the free end. This axis is enveloped in a layer (*o*) of longitudinal, striped, muscular fibres; which form the chief substance, in addition to a layer of polygonal epithelium cells, of the broad alary expansion on each side of the axis."

"The only unequivocal generative organ I found in *Appendicularia* was a testis (*p*), consisting of a mass of cells developed behind and below the stomach, enlarging so much in full-grown specimens as to press this completely out of place.

"In young specimens the testis is greenish, and contains nothing but small pale circular cells; but in adults it assumes a deep orange red-colour, caused by presence of multitudes of spermatozoa, whose development from the circular cells may be readily traced.

"This orange-red mass, or rather masses, for there are two in juxtaposition, is described by MERTENS as the 'Samen-behälter' or vesiculæ seminales. He describes them as making their exit, bodily, from the animal, and then becoming diffused in the surrounding water. This circumstance, indeed, appears to have furnished his principal reason for believing these bodies to be what the name indicates.

"The spermatozoa have elongated and pointed heads about 1-500th of an inch in length, and excessively long and delicate filiform tails.

"MERTENS describes as an ovary, two granulous masses, which he says lie close to the vesiculæ seminales, and have two ducts, which unite and open into this 'ovisac.'

"This appears to me to be nothing more than the granulous greenish mass of cells and undeveloped spermatozoa, which exists in the testis at the same time as the orange-red mass of fully-developed spermatozoa.

"I saw nothing of any ducts, nor do I know what the 'ovisac' can be, unless it be a further development of an organ which I found in two specimens (fig. 3 *q*), consisting of two oval finely-granulous masses, about 1-300th of an inch in diameter, attached, one on each side of the middle line, to the dorsal parietes of the respiratory cavity, and projecting freely into it."

"Still less am I able to give any explanation of the extraordinary envelope or 'House' to which, according to MERTENS,* each *Appendicularia* is attached in its normal condition. I have seen many hundred specimens of this animal, and have never observed any trace of this structure; and I have had them in vessels for some hours, but this organ has never been developed, although MERTENS assures us that it is frequently re-formed, after being lost, in half an hour.

"At the same time it is quite impossible to imagine, that an account so elaborate and detailed, can be otherwise than fundamentally true, and therefore, as MERTENS' paper is not very accessible, I will add his

* I have given this passage at length in order that others may be led to seek its explanation. Leuckart and Gegenbaur have been as unsuccessful as myself in finding any such structure; but that it should be purely imaginary seems past belief.

account of the matter, trusting that further researches may clear up the point.

"The formation of the envelope or 'Haus' commences by the development of a lamina from the 'semicylindrical organ' (ganglion?). This, as it grows, protrudes through the opening at the apex of the animal (respiratory aperture). Its corners then become bent backwards and inwards, and thus a sort of horn is formed on each side, the small end of which is turned towards the apex of the animal, while its mouth looks backwards, downwards and outwards.

"At the same time two other horns are developed upwards (the animal is supposed to have its small end downwards), one on each side. These are smaller and more convoluted than the others.

"This four-horned structure consists of a very regular network of vessels, in which, at the time of the development of the organ, a very evident circulation is visible; the blood-corpuscles streaming from the attached end of the organ. 'The clearness with which the circulation was perceptible, together with the great abundance of vessels and the large extent over which they were spread, were circumstances which led me (says Mertens) to believe this truly enigmatical structure to be an organ, whose function was the decarbonization of the blood. The ease with which the animal becomes separated from this organ is no objection to this view; the necessity there seems to exist for the reproduction of the latter rather confirming my opinion.'

"It is highly desirable that more information should be gained about this extraordinary respiratory organ, which, if it exist, will not only be quite *sui generis* in its class, but in all animated nature. And in a physiological point of view, the development of a vascular network, many times larger than the animal from which it proceeds, in the course of half an hour, will be a fact equally unique and startling."

"For my own part, I think there can be no doubt that the animal is one of the *Tunicata*. The whole organization of the creature, its wide respiratory sac, its nervous system, its endostyle, all lead to this view.

"In two circumstances, however, it differs widely from *Tunicata* hitherto known. The first of them is, that there is only one aperture, the respiratory, the anus opening on the dorsum; and secondly that there is a long caudal appendage.

"As to the first difference, it may be observed, that, in the genus *Pelonaia*,* an undoubted Ascidian, there are indeed two apertures, but there is no separation into respiratory and cloacal chambers. Suppose that in *Pelonaia* the cloacal aperture ceased to exist, and that the rectum, instead of bending down to the ventral side of the animal, continued in its first direction and opened externally, we should have such an arrangement as exists in *Appendicularia*.

"With regard to the second difference, I would remark, that it is just the existence of this caudal appendage which makes this form so exceedingly interesting.

"It has been long known that all the Ascidians commence their existence as larvæ, swimming freely by the aid of a long caudate appendage; and as in all great natural groups some forms are found which typify, in their adult condition, the larval state of the higher forms of the group, so

* I would particularly remark that the statement that there is no separation between the branchial and cloacal chambers in *Pelonaia* is erroneous. At the time this paper was written I had not examined *Pelonaia* (whose structure, as I have since found, differs in no essential point from that of an ordinary *Cynthia*), and I must have misunderstood the verbal information given by my lamented friend Professor E. Forbes.

does *Appendicularia* typify, in its adult form, the larval state of the Ascidians.

"*Appendicularia*, then, may be considered to be the lowest form of the *Tunicata*; connected, on the one hand, with the *Salpæ*, and on the other with *Pelonaia*, it forms another member of the hypothetical group so remarkably and prophetically indicated by Mr. MacLeay, and serves to complete the circle of the *Tunicata*.

In 1854 Dr. Rudolph Leuckart published, among many other valuable contributions to zoological science, a memoir on *Appendicularia* (for a copy of which I am indebted to the courtesy of the Author.)*

In several points Dr. Leuckart's view of *Appendicularia* differs from my own.

1. With regard to the "oval finely-granulous masses" attached on each side of the dorsal parietes, Leuckart states that they are by me considered to be "probably the ovaries." My words, it will be observed, hardly justify this assertion; I merely stated that they seem to be a further development of what Mertens *calls the ovisac*, which is a very different proposition. Dr. Leuckart's own view of these bodies, "that they are the earliest indications of the subsequently-formed stigmata," p. 84, is one with which I am, like Gegenbaur, unable to agree. In fact, as will subsequently appear, Dr. Leuckart has overlooked the true branchial apertures, unless indeed what he describes as the anus be one of them. The anal aperture, he states, is "situated on the right side, near the middle line, and exhibits a strong ciliary movement." Now, the anus is really in the middle line, and the ciliary movement which it exhibits could hardly be thus characterized, but, as will be seen below, the description would perfectly apply to one of the branchial apertures.

2. Dr. Leuckart failed to discover spermatozoa in the organ which is described by me as a testis. Nevertheless, it will be shown by-and-by that there can be no doubt that such is its real nature.

3. Finally, Dr. Leuckart arrives at the conclusion that *Appendicularia* is a larval form, and not, as I had suggested, an adult animal.

In 1855 Dr. Carl Gegenbaur, a very careful and excellent observer, published a memoir † on *Appendicularia*, containing the results of more extensive investigations than had hitherto been made. Adopting the view that *Appendicularia* is an adult form, Dr. Gegenbaur constitutes four species of the

* Zoologische Untersuchungen von Dr. Rudolf Leuckart, Heft. II. Salpen und Verwandte.

† Bemerkungen ueber die organization des Appendicularen, Siebold und Kölliker's Zeitsch, B.VI.

genus, *A. furcata*, *A. acrocerca*, *A. cophocerca*, and *A. cærulescens*. The most important and novel point in Dr. Gegenbaur's paper, however, is the discovery and description of the true branchial apertures, which had been overlooked by all previous observers, Dr. Leuckart and myself included. Dr. Gegenbaur says (l. c., p. 415)—

"If now we return to the branchial sac, the most remarkable objects are the two respiratory clefts which lie on its ventral wall and partially embrace the entrance into the œsophagus. Hitherto, none of those who have investigated the *Appendicularia* have recognised the true import of these organs, although Mertens saw them in *Oikopleura Chamissonis*, and Busch (in *Eurycerus pallidus*) would, in all probability, have understood them had he only borne in mind the typical structure of the Ascidians. Neither Huxley nor Leuckart have mentioned these respiratory apertures."

After describing the apertures, Gegenbaur proceeds—

"Exact observation shows that they are not simple apertures in the branchial sac like those of the Ascidians, connecting its cavity with the surrounding space; but that each is prolonged into a short tube which converges more or less towards its fellow on the ventral face."

In *A. furcata* these two tubes run

"At first parallel with one another downwards (if the animal be supposed to have its anterior part directed upwards, as in the figures), then form a knee-like curve inwards, running directly towards one another, and then entirely vanish, so that nothing more could be made out as to their mode of termination. The function of the respiratory apertures is therefore, in this case, entirely different from that which they perform in the Ascidians, in which the water passes through the branchial clefts, and, after aërating the blood contained in the network of the branchial vessels, collects in the space between the mantle and the branchial sac, to be eventually poured out of the cloacal aperture; while in our *Appendicularia* the water is led back by tubular prolongations of the branchial clefts into the body, so as either to become directly mixed with the blood, or by some further ramifications of the tubes to act through their thin walls on the surrounding blood. Which of these possibilities really occurs must remain, for the present, undecided; for although in *A. cophocerca* the end of the respiratory tube may be seen very clearly, yet it is still uncertain whether a bent prolongation of it may not be continued from this point, and may not, by presenting a transverse sectional view, give rise to the appearance of an end. I will enter no further in this place into the discussion of possibilities, my principal object being the statement of facts. However, I believe I have demonstrated that there is a tolerably-marked difference between the respiratory system of the Ascidians and that of the *Appendicularia*, expressed morphologically by the tube proceeding from the respiratory apertures of the latter."

Excessively puzzled to understand how structures so well marked and so obvious as these should have escaped my notice, I was, as may be imagined, very desirous to re-examine *Appendicularia*; but although its occurrence in the British

Isles was already recorded,* I hardly hoped to find it at accessible distances from the shore. During a few calm days last autumn, however, the water of the Bristol Channel, near Tenby, in Caermarthenshire, swarmed with *Appendiculariæ* (in company with annelide and crustacean larvæ, *Sagitta*, echinoderm larvæ, *Medusæ*, and *Noctilucæ*), very little different from the southern species which I had previously described, and I gladly seized the opportunity of repeating my observations.

The length of the body of different specimens varied very much; from one-fifth of an inch to a fifth or sixth that size. The caudal appendage was three or four times as long as the body, broad, flattened, and rounded at its extremity. The whole animal was usually colourless, except that the stomach had a brownish hue. In one instance, however, the caudal appendage was stained of a bright crimson colour, from what cause I know not.

With regard to the internal anatomy of the animal, I have, in the main, to confirm the statements I originally made. The oral aperture appeared to be more distinctly bilabiate than I had observed it to be in the southern species, the upper lip hanging over the aperture, and being, as it were, enclosed by the concave edge of the lower. The test forms a thick coat upon all parts of the body, except the posterior region, over the testis, where it is excessively thin. It often separates from the outer tunic in a very curious manner, becoming thrown into folds and sacculations; and I was almost inclined to seek here for Mertens' "Haus," had not his account been so circumstantially different.

The distance between the walls of the pharynx and the outer tunic appeared to be considerably greater than in previously-observed specimens, on the neural side, so that the blood-sinuses were here very large, becoming still wider near the ganglion, in consequence of the outer tunic being raised at this point into a transversely-convex protuberance, gradually diminishing towards the sides of the body. The pharynx is richly ciliated, and narrows posteriorly, its wall nearly following the contour of the stomach, so that it assumes the shape of a cornucopia, its tapering hinder portion bending up to terminate in the right division of the stomach. With regard to the endostyle, I have nothing important to add to my previous account, except that I believe it to be here, as in other Ascidians, the optical expression of the thickened bottom of a fold or groove of the branchial sac. The large apertures de-

* On the coast of Scotland. See Forbes and Hanley, "British Mollusca," vol. iv. p. 247.

scribed by Gegenbaur (c), at once strike the eye, not only from their size, but from the vehement action of the long cilia with which they are provided. I can in no way account for having overlooked them, and I see nothing for it but to accept the fact of the omission as a practical lesson in scientific charity. The pharynx passes on each side into a funnel-like prolongation (b, c), with its apex directed towards one side of the rectum. The dilated base of this prolongation is continuous with the pharynx, its comparatively narrow apex *opens externally* beside the rectum. In the mid-length of this conical canal is a thickened circular band (d), formed towards the pharynx of a series of cellæform bodies, placed in a single series, end to end, and externally to this of a transversely-banded substance. It is from this latter portion that the cilia take their origin. They are arranged in several tiers, are very long, and have a strong wavy motion,

That we have here a direct communication between the pharynx and the exterior, and not, as Gegenbaur states, a communication between the pharynx and certain internal canals, was made clear to me, not only by direct observation of the external apertures, but by feeding the animals with indigo. In two specimens this experiment succeeded perfectly; but it was very curious, that while in the one the current set *in* at the mouth and *out* at the apertures, in the other the current was in precisely the opposite direction, *in* at the apertures and *out* at the mouth. The wide stomach is bent backwards upon itself, so that its two halves or lobes are pretty nearly parallel, leaving, however, an interval in which the heart is situated. The right lobe is quadrate in outline, and undivided, but the left is irregular and lobulated. The inner surface of the stomach is papillose and ciliated, and many yellowish granules are scattered through the substance of its walls. The intestine arises from the upper angle of its left lobe, bends to the right, and then, when it reaches the middle line, passes forward to the anal aperture. The rectum is ciliated, and, as before, I was unable to find any trace of the tubular "hepatic" system, so general among the other Ascidians.

The heart (o) is large, and occupies a transverse position between the two lobes of the stomach, laterally, being more closely in contact with the right lobe, and the testis and base of the caudal appendage, antero-posteriorly. I was unable to observe any blood corpuscles, nor could I discover any sign of that reversal of the direction of the contractions so general among the other Ascidians. The absence of corpuscles would have rendered it almost impossible, under ordinary circum-

stances, to discover the direction of the circulating currents, but in one individual, the testis, having attained its full development, had broken up within the body, and the sinuses were filled with dark masses of spermatozoa. The heart, in full action, propelled these in a regular course up one side of the caudal appendage and down on the other (Müller has already described such a current in his '*Vexillaria*'), forwards on the hæmal side, and backwards to the heart on the neural side. This individual was particularly instructive also, by affording corroborative evidence as to the nature of the pharyngeal canals. Had these been in any way connected with the sinus system, as Gegenbaur supposes, the spermatozoa could hardly have failed to pass into them. Nothing of the sort occurred however; they passed round in the sinus between the walls of these canals and the outer tunic without the slightest extravasation, and their dark hue gave the contour of the canals only a better definition than it had before.

The testis was always present; small, discoid, and apparently attached by minute radiating filaments to the parietes in the younger specimens, it assumed the bilobed form in the larger ones, occupying a large space behind the alimentary canal. Individuals with fully-developed spermatozoa were comparatively rare. In that just referred to, the spermatozoa had rod-like heads, about 1-7000th of an inch long, with very long, delicate, and filiform tails; and the testis was reduced to a mere transverse band, the greater part of its substance having apparently been shed in the form of spermatozoa. Of a vas deferens I could find no trace.

The rounded bodies (m) on each side of the branchial cavity anteriorly, appeared sometimes to present an internal clear cavity, and might then be easily mistaken for ova. But the absence of any germinal spot, the uniformity in appearance of their bodies, in all individuals hitherto examined, and their position, are very great objections in the way of any such view of the matter.

I must confess that the evidence adduced by Gegenbaur appears to me insufficient to prove that the bodies which he describes in other *Appendiculariæ* as ovaria are such organs, and for the present I think it is safest to conclude that the female organs of *Appendicularia* are unknown.

With regard to the nervous system and the organs of sense, the only additional observations of importance refer in the first place to the caudal nerve, upon which I found at regular intervals small ganglion-like enlargements (Pl. X., fig. 4), from which, as well as in their intervals, minute filaments were given off to the adjacent parts. The largest of these ganglia

is the lowest, and when the appendage and the body are parallel, it is about opposite the end of the rectum. The nerve here receives a coat of minute rounded corpuscles, so that an oval mass, about 1-300th of an inch long, is formed, from whence numerous minute fibrils radiate. The other ganglia contain not more than two to five such corpuscles.

Gegenbaur states that if *Appendicularia furcata* be examined from the dorsal surface, an S-shaped cleft, ciliated at its edges, will be observed to the right of the ganglion. The cleft, which occurs only in this species, pierces the wall of the branchial cavity, and puts it in communication with the sinus system.

Seeking for this "cleft" in my *Appendicularia* (*flabellum—cophocerca?*), I came upon a slightly different, but I have no doubt, corresponding organ. This is a pyriform sac (*q*), about 1-800th of an inch in length, presenting at its wider end an aperture with a produced lip, communicating with the branchial cavity, and by its narrower extremity abutting upon the ganglion. The sac was richly ciliated within, and I have no doubt whatever that it is the homologue of that "ciliated sac," whose existence under different forms appears to be universal among the Ascidians. There is every reason, however, to regard this as an organ of sense, and it never communicates with the sinus-system, so that probably Gegenbaur's statement may be regarded as an error of interpretation.

I could discover no transverse muscles in the caudal appendage, but only an upper and a lower layer of longitudinal fibres, between which the axis of the tail was enclosed. Whether this central axis is a solid body, or a membranous capsule filled with fluid, I cannot say, but it is assuredly closed at both ends. Its closed and rounded proximal extremity is readily seen, and I feel confident that there is no such communication between the heart and the interior of the axis as Gegenbaur supposes. In the individual already referred to, in which the spermatozoa were effused into the general current of the blood, none entered the axis of the caudal appendage.

The discovery of the external openings of the pharyngeal canal and of the true nature of the supposed "ciliated cleft," appears to me to possess peculiar interest, in that it eliminates those structural peculiarities hitherto supposed to exist in *Appendicularia*, which were in discordance with the general plan of the Ascidians. That an Ascidian should have apertures in its pharynx, establishing a communication between its cavity and the sinus system, would be a great

anomaly; but that *Appendicularia*, being an Ascidian, should possess a ciliated sac, and that the wall of its pharynx should possess ciliated apertures or stigmata, establishing a communication between its cavity and the exterior, independent of the mouth, is only a strengthening of the evidence of its truly Ascidian nature.

Again, while the existence of these apertures establishes further most interesting relations of *representation* between *Appendicularia* and the larvæ of Ascidians, especially of *Phallusia*, it cuts away all ground for any supposed relations of *affinity* between the two. In *Phallusia*, it is true, as Krohn has shown, the cloaca is at first double, and each half, which might be regarded as the equivalent of the outer half of the pharyngeal canal in *Appendicularia*, opens by an independent aperture; but then the anus, instead of opening externally, terminates in one of these cavities. The enormous size, coarse ciliation, and very small number of the pharyngeal stigmata in *Appendicularia*, too, are wholly unlike anything larval.

The development of the nervous system and of the organs of sense is quite opposed to the supposition that *Appendicularia* is a larval form; and, in answer to Leuckart's suggestion that developed spermatozoa and ova are found in insect larvæ, I would urge that, in these matters, it is hardly safe to judge of one class by analogical arguments drawn from another. I am not aware that such early development of the reproductive products has ever been observed in any mollusk.

The discovery of the true branchial apertures in *Appendicularia* appears to me to bear no less importantly upon the moot question of the homologis of the Tunicata and Polyzoa, by removing all doubt as to the truly pharyngeal nature of the branchial sac in the Ascidians. But, if it be a pharynx, it cannot be the homologue of the conjoined tentacles of the Polyzoa, which are entirely pre-pharyngeal structures.

Whatever may be the result of future inquiries as to the arrangement of the female organs in *Appendicularia*, I cannot doubt that in *A. flabellum* we have an adult form in a male state. Whether the female has a totally distinct form, or whether the ova are developed in the same form at a subsequent period (I have observed individuals so young that it is hardly conceivable that the ova should be developed at an earlier period), is a problem of very great interest, but for whose solution I see no materials at present. Considering the abundance in which *Appendicularia* occurs on our own shores, the collection of the requisite data ought to present no

great difficulties to those who possess leisure and the opportunities of a sea-side residence; and to any such person, whose eye may fall upon these pages, I commend the investigation as one which will amply reward him.

NOTE *on the* REPRODUCTIVE ORGANS *of the* CHEILOSTOME POLYZOA. By T. H. HUXLEY, F.R.S.

OBVIOUS as are the ovicells and partially-developed ova of the *cheilostome Polyzoa*, the precise position of their ovaria and testis has not yet been determined; the general idea that the ova are developed within the ovicells being wholly an assumption. The investigation of the question is not without difficulty, on account of the delicacy of the ova in their young condition, the greater or less opacity of the ectocyst, and the obstruction offered by the other viscera if the cells be viewed in any of the positions which they ordinarily assume, lying, that is, on their front or back faces. By tearing up a polyzoarium, with needles, into single series of cells, and causing one of these series to lie upon its side, I found the process of examination much facilitated.

In the younger cells of *Bugula avicularis*, I find that, as in many of the hippocrepian Polyzoa, there is a cord, or funiculus, connecting the extremity of the stomach with the bottom of the cell, and attached to this I found, close to the stomach, a single small pale ovum, commonly possessing a double germinal spot. At its lower attachment, on the other hand, the funiculus is surrounded by a mass of minute, pale, spherical corpuscles. In these cells, no ovicells were as yet developed; but in older cells they make their appearance as diverticula of the ectocyst and endocyst, having their internal cavity continuous by a narrow neck with that of the cell. A valvular aperture eventually becomes developed at the lower part of their anterior face.

In such older cells, the ovicell is at first empty, and we find the ovum attached to the funiculus increasing in size, and acquiring a reddish coloration; but in those still further advanced, a similar, but larger and redder, body makes its appearance in the ovicell, and after undergoing yelk-division becomes a ciliated embryo. In these older cells, again, we find the granular mass at the bottom of the cell gradually developing into a mass of spermatozoa, which eventually float loose in the cavity of the cell.

I have no doubt, therefore, that in *Bugula avicularis* the ovarium is situated at the top of the funiculus, the testis at

its base; that impregnation takes place in the cavity of the cell, and that the ovum passes from thence into the ovicell—there, as in a marsupial pouch, to undergo its further development. The testis has a similar form and structure, and its position is invariably at the bottom of the cell in *Bugula flabellata*, *B. plumosa*, and *Scrupocellaria scruposa*, but that of the ovarium varies greatly. Thus in *B. flabellata* the ovarium is placed at the middle of the back of the cell, and is not directly connected with the funiculus; in *B. plumosa*, it lies at the apex of the back of the cell; in *Scrupocellaria scruposa*, it is at the upper and back part of the cell. The ovarium rarely presents more than one or two ova.

On the REPRODUCTIVE ORGANS *of certain* FUNGI, *with some remarks on* GERMINATION. NO. II. By FREDERICK CURREY, Esq., M.A.

THE following paper is intended as a sequel to a previous communication on the same subject which appeared in the last volume of this Journal (see vol. iii., p. 263.) The instances in which a particular fungus has been observed to produce a variety of fruits differing essentially from one another, are already very numerous, and are daily on the increase. This polymorphism of fructification is highly interesting and important, not only in a physiological point of view, but from the effect which it must necessarily have upon the classification of the vast tribe of Fungi. Not only have different genera of the same order been already proved to be identical, but Fungi originally classed in different orders, and apparently of widely-different habits and structures, have been proved to be the produce of the same mycelium. The facts which I proceed to mention, are principally the result of observations made since the publication of my former paper, and they will, I hope, be considered interesting additions to this branch of microscopical science.

1. ASTEROSPORIUM HOFFMANNI—*Kunze.*—The fungus known by the name of *Asterosporium Hoffmanni* is a plant which is frequently met with in this country upon twigs of beech. It was originally ranged under *Stilbospora*, but was separated by Kunze as long ago as the year 1819, and erected into a separate genus. Although the very peculiar shape of its spores affords some grounds for this separation, the plant accords in every other respect with *Stilbospora*, in which genus it is still retained by some mycologists. Each one of the

spores of this singular plant consists of four bi, tri, or quadri-septate pointed cones radiating from a common centre, but the axes of which do not lie in the same plane. I have called the rays cones, but this is not strictly correct, inasmuch as they are generally slightly curved like a cow's horn. The spores have been compared to the instrument called *crow's-feet*, which, when thrown on the ground, always present one point upwards, as would manifestly be the case with these spores. In fig. 1, Pl. XI., I have represented a spore as seen under a magnifying power of 500 diameters. I would observe, that although the normal number of rays is four, I have met with spores in which two of the rays have failed, thereby producing the appearance shown in fig. 2, which represents one of these abnormal spores magnified 350 diameters. Spores of this latter kind were tolerably numerous in one or two of the specimens which I lately examined, and upon which the observations to which this paper relates were made. The threads of the mycelium are of a brownish colour, sometimes septate, and not unfrequently branched. In the specimens just mentioned these threads were so closely packed as to present somewhat the appearance of a membrane composed of elongated cells, but nevertheless, upon close inspection, it might be seen that the threads were not actually adherent to one another. The spores of *Asterosporium*, like those of the *Stilbosporæ* in general, eventually produce a fissure in the bark under which they grow, and are ejected from beneath the epidermis; if the atmosphere be moist they have the appearance of tubercles of black jelly covering the twigs upon which the plant grows, but which tubercles, in hot weather, cease to be gelatinous, and become hard and dry.

I must now direct attention to a plant which has hitherto been considered quite distinct from *Asterosporium*, and which bears the somewhat uneuphonious, but withal expressive, name of *Myriocephalum botryosporum*. This fungus, which has all the characters of a *Stilbospora*, was placed by M. Montagne in that genus, but has borne a variety of names. It is the *Cheirospora* of Fries, the *Rhabdosporium* of Chevallier, the *Hyperomyxa* of Corda, the *Botryosporium* of Schweinitz, and the *Myriocephalum* of De Notaris, and Fresenius. It may be recognized under the microscope at a glance, by the peculiar grape-like bunches of green spores borne on the apices of long slender filaments, which are sometimes, though not generally, branched. Fig. 3 represents the upper part of one of these filaments terminating in a bunch of spores; and fig. 4 represents a similar bunch of spores, in which, as I have observed to be the case in many instances, the terminal spore, and

sometimes the *two* upper spores, considerably exceed in diameter those spores which are lower in the chain. Fig. 3 is magnified 500, and fig. 4, 350 diameters.

In the first week of January in the present year, several dead branches of a beech-tree, in a wood near the Weybridge Station of the South-Western Railway, were covered with spots, each consisting of a small circular black stain, with a central papilla. A few days later, a large quantity of rain having fallen in the interval, and the atmosphere having been unusually moist, the spots had increased considerably in size, and assumed a pulvinate or hemispherical shape. A vertical section of one of these pulvinuli, carried down through the bark, presented the appearance shown by fig. 5. The epidermis was lifted up, and a conical cavity formed between that and the inner bark. This conical cavity was completely filled with the brown-coloured mycelium above-mentioned, the threads of which lay excessively close to one another. This mycelium was covered with the ordinary spores of *Asterosporium Hoffmanni*, similar to the one shown in fig. 1. In one or two of the plants many of the spores of the *Asterosporium* had assumed the form shown in fig. 2, and in other instances, multicellular spores without horns existed in considerable quantities, always towards the lowest portion of the conical cavity. The gelatinous tubercle which crowned the cavity, and the section of which is seen in fig. 5 above the laciniæ of the epidermis, consisted of elongated white threads enveloped in a mucous medium, each thread bearing at its apex bunches of spores such as those shown in figs. 3 and 4. A careful examination of a number of specimens quite satisfied me that the white threads were prolongations of the brown mycelium, the threads of the latter becoming gradually narrower and paler in colour in approaching towards their summit. In short, the pale brown filaments which filled the cavity beneath the epidermis, and which bore the spores of the *Asterosporium*, and the elongated whiter filaments, which traversed the mucous substance of the gelatinous tubercle, constitute but one of the same mycelium, a fact which necessarily leads to the interesting conclusion that *Asterosporium Hoffmanni* and *Myriocephalum botryosporum* are only varieties of fruit of the same fungus.

The forms above mentioned, however, are not the only produce of this fertile mycelium. The moist atmosphere which converted the dry papillate black spots into gelatinous tubercles, had the effect of producing a further fructification in the form of white colourless elliptical bodies, conidia in fact, which were produced in abundance on the upper por-

tions of the threads of the mycelium. In some specimens the grape-like bunches of spores were literally floating in a sea of these conidia, which were so numerous that I can only compare them to the mass of similar bodies which may be seen under the microscope at any time by moistening a specimen of *Tubercularia vulgaris*. These conidia spring laterally from the threads upon which they grow, and are, I think, produced in moniliform rows. They can seldom, however, be observed *in situ*, on account of the rapidity with which they are shed when the plant is moistened. Fig. 6 represents several of these conidia magnified 500 diameters.

In the Uredines, where the dimorphism, or rather polymorphism, of the fruit has been so clearly established, the constant occurrence in the same matrix of the different sorts of spores was observed long before it was proved that these varieties were the produce of the same mycelium. Now *Asterosporium Hoffmanni* is, as I have mentioned, a common plant, and *Myriocephalum botryosporum*, although it is not nearly so well known, and has not, as far as I am aware, ever been found in this country before, has, nevertheless, been noticed by several continental mycologists, none of whom, however, have suggested the identity of the two, or have even mentioned their association in growth. Fries, in the 'Summa Vegetabilium Scandinaviæ,' has noticed the close connexion existing between *Hyperomyxa*, *Myriocephalum*, *Asterosporium*, and the *Stilbosporæ* in general. He says, speaking of the two former, "Mediante *Asterosporio* cum veris *Stilbosporis* manifeste seriem contiguam sistunt: omnibus eadem genesis vegetatio, stroma mucoso-floccosum, e. s. p." Even Fries, however, has not suggested the identity which I hope to have established.

These remarks must not be considered as being made at all with the view of magnifying the importance of the discovery, but solely for the purpose of calling attention to the fact, that since so many distinguished mycologists have had both plants under their observation, and have not noticed their association, it is probable that the occurrence of the two kinds of fruit contemporaneously is a circumstance of rare occurrence. We know little, if anything, of the atmospheric conditions necessary for the favourable growth of particular Fungi; the mycelium of *Agaricus strobiliformis* has been known to lie dormant for 14 years, and yet the Agaric, the fruit of that mycelium, has appeared after that lapse of time true to its former locality. May not the coexistence of the two fruits of the *Asterosporium* be dependent upon peculiar atmospheric conditions, and be of as unfrequent occurrence?

I have spoken of Corda's genus *Hyperomyxa* as being identical with *Myriocephalum.* The only distinction is, that Corda represents each thread and each fascicle of spores as enveloped in a separate mucous sheath. There can be no doubt, I think, that these mucous sheaths form, by their dissolution, the gelatinous mass in which all the flocci and capitula of spores are enveloped. In the 'Summa Vegetabilium Scandinaviæ,' the genus *Hyperomyxa* immediately precedes *Myriocephalum,* and upon the former Fries makes the remark, "Forte non satis diversum a sequente; in quo vagina (l. ascus) jam primitus resorbtus ut sporæ nudæ sint." "Nudæ" here must mean naked, so far as regards any *special protective organ,* for of the existence of the general mucous envelope there can be no doubt.

The dampness of the atmosphere at the period of the above observations was of course favourable to germination, and I observed many germ-filaments amongst the mass of the *Myriocephalum* spores. A remarkable feature in these germ-filaments was their great diameter as compared with that of the individual joints of the torulose capitula. This is so striking as almost to induce the belief that each capitulum germinates *as a whole.* In fig. 7, I have drawn one of these germ-filaments under a power of 350 diameters, and an inspection of that figure will show its great width. The filament is divided by a multitude of transverse septa, and the contents of each cell are granular with two or three nuclei. The colour of this particular one was a deep sea-green, much darker than is usually the case with the germ-filaments of Fungi, but others occurred which were almost colourless.

In the 'Botanische Zeitung' for the 25th of February, 1853, Dr. Riess describes a new species of *Prosthemium,* which he calls *Prosthemium stellare,* and which bears a tuft of spores analogous to *Myriocephalum.* He suggests that the entire fascicle may, perhaps, be considered to be a single highly-developed spore. If the same supposition could be made in the case of the *Myriocephalum,* it would at once explain the apparently unprecedented size of the germ-filament; but whether or not such a supposition be admissible I am not prepared to give an opinion.

It remains to say a few words with respect to the name by which the plant here discussed should henceforth be distinguished. I think there can be no doubt that it should be retained in the genus *Stilbospora.* Although it has become common lately to speak of the *Stilbosporæ* as only stylosporous states of *Sphæriæ,* it is obvious that the genus cannot be

extinguished until more has been effected than has yet been done towards tracing the different species to their perfect ascigerous condition. Inasmuch as *Asterosporium* and *Myriocephalum* have both been placed, the one by Montagne and the other by Persoon, in the genus *Stilbospora*, the best course, now that they prove to be the same, will be to retain them in that genus with an appropriate specific name. For the latter I should propose the term "*militaris*," since both kinds of fruit resemble instruments of warfare—the stellate spores being similar to crowsfeet. and the fasciculate spores being something like grape-shot. In case any of my readers may not be familiar with the former instruments, I may state that *crowsfeet* consist of a spherical piece of iron with four spikes concentric with the sphere, and radiating from it in different planes. They were formerly used by throwing them in numbers on the ground, with the view of laming the enemy's horses.

Steganosporium cellulosum.—This plant has not yet been recorded amongst the British Fungi, although I can hardly believe that it has not been observed. The genus was separated by Corda from *Stilbospora* on the ground of the more compound nature of the spore. He distinguishes two species, *Steganosporium pyriforme* and *S. cellulosum;* there does not, however, seem to be any substantial difference between the two, for the existence or non-existence of longitudinal septa in the spores is clearly unimportant, inasmuch as spores are to be found in the same specimens some with and some without such septa. The difference in the nature of the perithecium is also, I think, insufficient to justify the separation of the two species, even if such difference be not (as I suspect it is) dependent merely upon accidental circumstances of growth. It would probably, therefore, have been better to follow Fries, and to have united the two species under the common name of *Stilbospora cellulosa;* but the following observations will, I venture to think, be considered sufficient to show that *Steganosporium cellulosum* and *S. pyriforme* are only forms of fruit of a *Sphæria* allied to, if not identical with, *S. amblyospora*.

In July, 1855, I found a dead branch of a Sycamore in my garden at Blackheath covered with *Steganosporium cellulosum*. With the view of ascertaining whether any other fungus lay dormant in its vicinity, I placed some pieces of the branch in a green glass bottle with some damp moss, corked the bottle tight, and exposed it to the full mid-day sun. In a few days the ostiola of a *Sphæria* appeared on one of the pieces of

stick, and upon examining the *Sphæria* I found the asci (figs. 8 and 9) mixed with the *Steganosporium* spores (figs. 10—15) in the same perithecia. This would seem to show satisfactorily that the *Steganosporium* and the *Sphæria* are identical, a conclusion which was fortified by a further examination of the specimens of the former Fungus. Careful sections of these latter plants disclosed the existence of the bodies represented in figs. 16, 17, 18, and 19. These bodies were seen *in situ* attached to the stratum proliferum (it can hardly be called perithecium) of the *Steganosporium*. Figs. 16 and 17 can be nothing else than empty asci; they have precisely the shape of these latter organs, and exhibit very distinctly the internal second membrane common to the asci of Fungi in general.* Figs 18 and 19 are also, I think, manifestly imperfect asci. In fig. 19 the internal membrane is clearly visible at the lower extremity, and in each of them the endochrome is divided into eight distinct, somewhat irregularly-shaped fragments, which may fairly be assumed to be incipient or abnormal sporidia. These bodies (figs. 16 to 19) were, as I have mentioned, attached to the stratum proliferum, and were situated at the bottom of the lenticular cavity from which the cirrhus of the *Steganosporium* spores emerged; the ejected mass or cirrhus consisted almost entirely, if not exclusively, of these spores, which are shown in figs. 10 to 15; and the same spores also filled the middle of the cavity, whilst the lower portion of it was covered exclusively with the organisms drawn in figs. 16 to 19.

With regard to the *Sphæria*, the asci and sporidia drawn in figs. 8 and 9 will enable the reader to form an opinion as to the species. I have little doubt that it is *Sphæria amblyospora*, a species which I have found on another occasion associated with *Steganosporium cellulosum*. The sporidia, however, are much more obtuse than is usual with *S. amblyospora*, in which the successive cells generally decrease rapidly in size from one end to the other, rendering the sporidium truly lageniform. The bottom sporidium in the ascus, fig. 9, is nearly the normal form in *Sphæria amblyospora*. In this latter ascus, where the sporidia are not quite ripe, the gelatinous envelopes seen in fig. 8 were not visible, and the sporidia were of a much paler colour than in fig. 8.

* In figs. 32, 33, I have drawn two asci of *Sphæria herbarum*, which I have observed to dehisce in a singular manner. In fig. 32 the top of the ascus appears to have been carried upwards, and the internal second membrane is visible at both ends. In fig. 33 the ascus has opened as it were with a hinge; the second membrane is reduced to a thread, which is attached to and encloses a single sporidium.

Fig. 20 represents a ripe sporidium from the same perithecium as the ascus fig. 8. Fig. 21 is a sporidium from another specimen of *Sphæria amblyospora*. This sporidium, it will be seen, has its envelope fully developed, and its colour, like that of all those which were quite ripe, was a dark olive-brown. Most of the sporidia in all the specimens had three septa, but some had two, and a few only one.

By placing the spores of the *Steganosporium* in water under thin glass, and securing them from evaporation, I found that they germinated without difficulty, and the forms assumed by them at the commencement of that process were very curious. Several of the partitions into which the spores were divided threw out contemporaneously slender white filaments, the colour of which contrasted strongly with the dark green of the spores. At this stage of the process the spores (Figs. 22, 23, 24) with their shoots had the appearance of large insects, the spores representing the bodies, and the germ-filaments the legs. One of these germinating spores had a round vesicle attached to the extremity of one of the germ-filaments, but whether this vesicle was really the expanded apex of the filament or the spore of some other Fungus accidentally adherent, I cannot say with certainty. The latter is not improbable, for every Mycologist must be aware that notwithstanding the greatest care in cleaning, the spores of some previously-examined Fungus will frequently adhere to the slides, and if care be not taken to distinguish such interlopers, erroneous conclusions may be the result. Fig. 25 represents a spore in which the germ-filament has attained a considerable length, and has thrown out lateral branches in many directions. A few days later fresh branches had been produced from the main filament, and further lateral shoots from these fresh branches, the whole forming such a complicated maze of filaments that any attempt to draw them with the Camera lucida would have been quite hopeless. The filaments were of a somewhat greenish colour with granular contents, and a multitude of small nuclei were scattered here and there irregularly throughout their whole extent.

It will be seen by comparing figs. 10—15 and figs. 22—25, that the *Steganosporium* spores vary much in size and shape. The colour is constant, being a dull olive-green.

Sphæria Cryptosporii.—In the former paper to which I have referred, I described a new species of *Sphæria* under the above name, and at the same time certain facts were brought forward, which appeared to show that the Fungus known by

the name of *Cryptosporium vulgare* is only an imperfect state of this particular *Sphæria.* During the last autumn I met with the same *Sphæria* in two places, in the neighbourhood of Chislehurst, in Kent; and the further examination which I had then an opportunity of making, not only confirmed the previous supposition of the identity of the *Sphæria* and the *Cryptosporium*, but also disclosed the existence of some curious transformations of the fruit of the former, which are worthy of notice. The normal form of the fruit of *Sphæria Cryptosporii* is shown in fig. 26, and figs. 27 to 31 represent the varieties of fruit just mentioned. The bodies shown in figs. 27 and 28 resemble the common spores of *Cryptosporium vulgare*, although their length is more considerable, and they have an undulating form, which is not usual in these spores. In fig. 28 two are seen, which have become twisted round one another. It appears to me that these bodies may be elongated asci, in which the endochrome instead of forming sporidia has remained dispersed throughout the interior in a granular condition. A reference to my former paper, and to the figures accompanying it, Plate XII. in Vol. iii., will show the manner in which, according to my view, the formation of sporidia from the endochrome takes place. In fig. 29 the lower end of the ascus has become transformed into a globular vesicle, in which a considerable quantity of the endochrome from the upper end has become accumulated. No symptom of the formation of sporidia is visible either in this or in the two other abnormal asci represented in figs. 30 and 31. In the one shown in fig. 30, the ascus has apparently become swollen at the *upper* extremity; and in fig. 31 the two ends are elongated, and a globular vesicle has been formed between them.

I have observed transformations very similar to the above to take place in the fruit of *Sphæria verrucæformis;* but the figures and description of these would occupy so much space that I must postpone them for a future communication. I think it not unlikely that these monstrosities of fructification are the result of excess of moisture; but this is a matter requiring further investigation.

On the SIMILARITY *of* FORM *observed in* SNOW CRYSTALS *as compared with those of* CAMPHOR *under certain conditions of* CRYSTALLIZATION. By JOSEPH SPENCER, Esq. (Read before the Greenwich Natural History Club, Jan. 2, 1856.)

INVESTIGATIONS tending to throw some light on the laws which determine the external forms and internal structure of crystallized bodies, may not be considered devoid of interest. The field of research is so extensive, the forms of crystals so varied and beautiful, and a knowledge of their primitive and resulting forms of such importance to the kindred science of chemistry, that any additional facts on the subject may be considered desirable. Much attention has been given of late to the peculiar forms assumed by snow, or to speak more correctly, by water under certain conditions of crystallization. The subject was first introduced, I believe, by a distinguished member of this Society, and has since been most ably worked out by him. Every one must have been struck with the beauty and variety of snow-crystals, and some very truthful delineations of them have been published. A great difficulty sometimes has been felt by those desirous of studying them from their very perishable nature, as they require to be maintained at a temperature below the melting point of ice, or 32 degrees of Fahrenheit's thermometer. The usual plan of viewing them has been by the microscope in the open air, or at a window. Having tried both plans, and found them beyond my powers of endurance for any length of time, I have been driven to devise a plan for viewing them within doors, and in comparatively warm rooms. This plan I shall be happy to explain, at the conclusion of this paper, to any members of this Society who may be interested in the subject. Very considerable interest attaches to the forms assumed by snow, from the intimate connexion that appears to exist between the production of certain forms of crystallization, and certain states of the atmosphere. Meteorology has of late years obtained that attention which its importance deserves, as only by a slow and laborious collection of facts, extending over a series of years, can we hope to arrive at a knowledge of the laws which control the mighty agencies at work in the atmosphere of our earth, and the study of which is of such importance to the health and well-being of man. It would be very desirable, however, in the study of snow-crystals, to find some substance similar in its habits of crystallization but of a less perishable nature, and which would enable us to trace the progress of the crystals from the simplest up to the most complicated forms; so that reasoning

by analogy we might be able to throw some light on the subject.

The well-known substance, *camphor*, I find, fulfils all these conditions, and possesses some peculiar properties that make it an interesting subject of study. Some of these peculiarities have been long known; and I believe that the old-fashioned instrument or philosophical toy, called the weather-glass, was a tube hermetically sealed, and containing a solution of camphor. Camphor, crystallized slowly, does not usually assume the form of hexagonal crystals, but like snow or ice takes the arborescent form, very similar to the fronds of Ferns: this may often be observed in the case of ice in the beautiful forms assumed on the surface of windows in winter. Camphor usually takes the same form under like conditions, but requires a rapid crystallization to produce hexagonal crystals. The most convenient way to repeat these experiments on camphor is to make a solution of this substance in alcohol or spirits of wine, and add thereto some water of ammonia—the precise quantities are not of much moment, provided there be an excess of camphor undissolved. I usually add a small quantity of water to the clear solution drop by drop, till the precipitated camphor ceases to be redissolved. The simplest form assumed by crystallized camphor is a flattened disc: very frequently two discs are united together by a smaller one in the centre, giving rise as the process of crystallization goes on to twin crystals, superposed one on the other precisely like snow crystals. These discs frequently possess what appears to be a nucleus, which is coloured more or less; the disc and nucleus differing in colour, the colours being most frequently complementary to one another. I had proposed to myself to mount some of these hexagonal crystals of camphor to exhibit to the Society, but have found a difficulty in obtaining a suitable medium which would not possess a solvent action upon them: they are so readily procured, however, by a rapid evaporation of the solution of camphor under the microscope, that this will hardly be an objection. It must not be expected that we should meet with that infinite variety of form observed in snow crystals in the case of hexagonal crystals of camphor, since we can only produce them on a very small scale, compared with the millions we can select from in the case of snow. My object, therefore, has been, in introducing the subject to the notice of the members of this Society, to draw their attention to it as an interesting subject for experiment during leisure moments in the course of the winter, when most probably they will have an opportunity of comparing

for themselves the crystals of snow and of camphor, and of throwing still further light on the subject.

Further Observations on the SIMILARITY *of* FORMS *observed between* SNOW CRYSTALS *and those of* CAMPHOR. By JAMES GLAISHER, Esq., F.R.S. (Read before the Greenwich Natural History Club, Feb. 6, 1856.) Plate XII.

THE field of inquiry thus opened by Mr. Spencer has since engaged a portion of my attention. The following are some of the results of observation carried on at intervals, the solution being provided by Mr. Spencer, and a part, I believe, of that employed by him in his own experiments. The following are my notes on the subject.

The process of crystallization, according to my own observation, appears to proceed rapidly, and to commence simultaneously with the action of the air upon the liquid; but to be by no means certain of proceeding similarly under apparently similar conditions.

The process of crystallization, in this case, bearing the closest analogy to that of snow, and the one of most frequent occurrence, presents an endless succession of minute, round, moving dots, passing to and fro with the restless movement of animalcules; every instant these globules very perceptibly increase in size, and soon develop points, generally six in number, which continue to enlarge until they assume the character of arborescent pinnæ, the additions to the elementary figure being effected at an angle of 60°. The crystal, when arrived at perfection, immediately begins to simplify, and continues to do so until quite evaporated. If, however, the room be cool, and the evaporation proceed slowly, as is best in these experiments, it is not unusual to perceive one or two of the radial arms elongating themselves at the expense of the rest, and the greater number subsiding into a kind of crystalline film or disc, of which I will speak presently.

These figures never appear to attain to any great degree of complexity, or to be other than arborescent when in their final and most perfect stage of development. In some of the richer specimens may be seen, around the nucleus, a somewhat thick aggregation of little drops or knobs; but these are not arranged with the geometrical precision to be observed in the crystals of snow, and speedily disperse into the crystalline matter of the arms, to which they contribute a still more arborescent character. The downward and tertiary spike, common to the snow crystal, is here often met with, and forms a point of analogy worthy of remark.

One main difference between these and the figures of snow, is that they exhibit an entire want of angularity, and only approximate, even when at their greatest perfection, to the snow crystal just as it appears before finally dissolving. Moreover, they have at all times a watery, uncertain, fluctuating outline and appearance generally, as though viewed through a watery medium; even the disc into which they generally subside, presents the same indefinite wavy outline, and the transparency of the parts is rather that of globules of water than of crystals.

These peculiarities attach to them at all times; but the appearance of the field differs very considerably, under, to all appearance, similar circumstances of observation. Sometimes it is covered with minute globular bodies (crystals in embryo), which quickly settle close to each other in clusters, and never go beyond the figure of a well-defined star. Sometimes they may be seen in fewer numbers, swiftly travelling over the field; some single, but the greater number double, for they share in this respect a peculiarity of the snow crystals, but differ in their being united by a point of contact common to the two, instead of being united by a slender axis as in the crystal of snow. As they roll over, their conformation is distinctly visible; and it is curious to watch the double process of development as the star emerges from the elementary globule, which is every instant perfecting itself to the complete figure, when it settles down and remains stationary till the moment of its final departure. Sometimes they unite in rows, sometimes in clusters so intermixed that the individual forms are not distinguishable.

The greater number of these figures, indeed I may say it is the rule with them, crystallize at an angle of 60°; there are, however, exceptions, and on one occasion I failed to discover any other than eight-rayed crystals, arborescent and differing only in regard to the additional radii. They have all of them, with few exceptions, a nucleus generally circular but sometimes star-like, with parallel and inner markings.

I have made mention of a flattened disc into which these bodies disperse. This disc is in itself a most interesting study; it is curiously intersected in different directions by sinuous channels of different densities. It forms quickly; and when the room has been overheated I have seen the field covered with discs with instantaneous rapidity, without exhibiting a trace of stellar crystals. Sometimes the disc forms round one-half of the crystal, dissolving the parts in contact with itself.

This is all that I have been able to collect respecting these

bodies, which chiefly resemble the crystals of snow in their hexagonal, stellate, arborescent shape and in the form of their pinnæ. If not, however, intimately allied, it is interesting to observe and compare the manner of their change; and a continuation of these observations, varied by experiment and the employment of other solutions, may yet afford information on a subject which, as Mr. Spencer remarks, is of peculiar interest, as uniting the confines of meteorology and chemistry.*

On an Easy Method *of viewing certain of the* Diatomaceæ. By John Charles Hall, M.D., Physician to the Sheffield Public Dispensary, &c. &c.

We shall most certainly add not a little to the chances of increasing our knowledge of the intimate structure of the infusorial tribes, if any means can be suggested by which the number of observers may be increased. Possessed of a good microscope by one of our principal makers, a student may imagine that he is in a condition at once to ascertain the exact form and nature of certain shells of Bacillaria, certainly amongst the most difficult of test objects; a very few trials will, however, convince him that even the best-constructed *eighth* will not fully display their peculiar markings without some accessory instrument. For this purpose the achromatic condenser of Mr. Gillet, as made by Mr. Ross, or the achromatic condenser of Powell and Lealand, or of Smith and Beck, is usually employed. The purse, unfortunately, of the most enthusiastic labourers is not always the heaviest; a microscope is bought and added to from time to time, and the condenser, so much coveted, must often be waited for some years.

We propose in the present paper to show how, for a few shillings, this apparatus may, for a time at least, be dispensed with; and how the *Pleurosigma Hippocampus*, *Pleurosigma formosum*, *Pleurosigma angulatum*, and other individuals of this genus, may be shown in the most satisfactory manner;

* An infinite variety of crystalline forms, apparently allied to those of snow and of camphor, is presented, when a drop of a weak solution of common salt, to which a small quantity of *urea* has been added, is dried at a moderate temperature on a slip of glass held over a spirit-lamp. The change produced by urea in the shape of the crystals of common salt, from the octahedron to the dodecahedron, or some derivative, has been long well known; and the fact may be usefully employed, with certain precautions, to determine, under the microscope, the presence of extremely minute quantities of *urea* in animal and other fluids.—[*Eds.*]

and we almost envy the sensation of delight which must be experienced on using this simple means of illumination, and beholding for the first time the wonderful markings and brilliant colouring of many of these dust-like atoms, found alike in the clearest waters, in the strongly acidulated, and in the salt fluids of the various zones of the earth. "In springs, rivers, lakes, and seas, in the internal moisture of living plants and animal bodies, exists," says Pritchett, "a world, by the common senses of mankind unperceived; for, in the ordinary pursuits of life, this mysterious and infinite kingdom of living creatures is passed by without knowledge of, or interest in, its wonders." To facilitate the investigation of these wonderful organizations the present paper has been written.

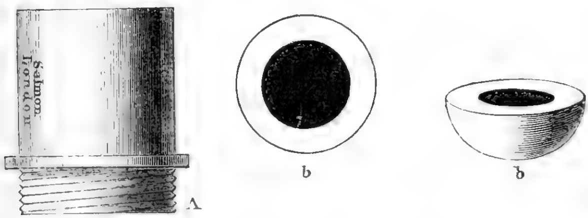
The discovery of this method of exhibiting the *Pleurosigma angulatum* was perfectly accidental, and so far as I know it has not been published; at any rate, Messrs. Powell and Lealand were wholly unaware that such an effect could be produced, on my communicating it to them.

With many microscopes is furnished, for the purpose of a dark-ground illumination, what is called a "*spotted lens;*" by this means the object itself appears beautifully illuminated, while the entire field by which it is surrounded is perfectly dark; the effect is produced by preventing any rays of light, reflected from the mirror, passing through the object: this is accomplished by placing a dark stop beneath the latter. The arrangement, however, is such, that any oblique rays will impinge upon the object, and after they are refracted by it, they will pass into the object-glass; consequently, the result being, that the only rays transmitted through the instrument, are those thus refracted from the object, it appears beautifully bright whilst the surrounding field is black. The accompanying engraving explains the instrument used by myself, the cost of which was only 7*s.* 6*d.*: *a*, the brass tube, fitting either into the usual brasswork of the achromatic condenser of Smith and Beck, by which it can easily be moved up and down and correctly adjusted; or, as in the microscopes of Mr. Salmon, into a small piece of tube adapted to the diaphragm; *b b*, the lens removed from the tube. The drawings are the exact size of the different parts of the apparatus.

This instrument is usually employed with the lower powers (*the inch* and *two inches*), when the appearance is that already described. On using it with a quarter constructed for me by Mr. Ross, the angular aperture of which is 85°, with a 1-5th of Smith and Beck's (angular aperture of 100°), and with a

very beautiful 1-8th (angular aperture 126°), made for me a few months ago by Powell and Lealand, I was astonished to find a field perfectly clear and white, and the illumination little, if at all inferior, to that produced by Gillet's condenser, or the one I generally use myself, which was made for me by Smith and Beck. The first object I tried it with was *Pleurosigma angulatum* (the *Navicula angulata* of Quekett), which after a little trouble I was enabled to exhibit most beautifully in dots; and two experienced friends, Dr. Branson and Mr. Gregory, in common with myself, were much struck, not only with the very beautiful manner in which the object was shown, but also with the rapidity with which the adjustment could be effected.

An experienced artist, Mr. C. J. Fleming, has carefully sketched, from my microscope, the actual appearance of the objects shown with this peculiar illumination, which at once places in the hands of every student a ready and very cheap method of exploring a field abounding with objects of the most wonderful forms, and the internal structures of which, as organized living beings, cannot fail amply to repay the most diligent research.



These drawings, most beautifully engraved by Mr. Tuffen West (Pl. XIII.), will show the student what he has to look for, and so far as I know they give a better representation of these beautiful objects than any yet published; for however well calculated the plates in the works of Quekett, Pritchett, or Smith, are to show the forms of the different *Diatomaceæ*, they fail, to my eye, to do justice to the wonderful appearances actually exhibited by these shells. Perhaps it should be added that the glass I generally use is an eighth, constructed by Powell and Lealand; with a 1-5th of Smith and Beck, or a 1-4th of Ross, the markings may also be very well seen. The light was obtained from the very complete gas lamp of Mr. Highley.

In order to show these objects in a satisfactory manner, the most careful manipulation is required; they must be

covered with the thinnest possible glass, and the slide should be perfectly clean and free from damp, otherwise the field will have a milky appearance. In using the spotted lens, every part of the microscope must also be perfectly clean and free from dust; the *concave mirror* should always be used with it. When due precautions are taken, points of structure can with its aid be easily made out not seen by the ordinary methods of illumination.

What may be the exact nature of the striæ is not easy to determine. "Whenever," says Mr. Quekett, "these infusoria are viewed under the most favourable illumination, either from a white cloud or a lamp with direct light, and a magnifying power of at least 1,200 diameters, the lines are all shown to be dots or elevations from the surface." * The Rev. W. Smith † considers the true character of these markings to have been mistaken: "some observers having considered those appearances to arise from a series of perforations, others from rows of beads or minute elevations." From the close manner in which the striæ are arranged, their resolution is amongst the most difficult tasks in microscopy. After having given to the subject no little care and attention, with an eighth object-glass made by Messrs. Powell and Lealand (the beautiful defining powers of which it is impossible to estimate too highly), and a very deep eye-piece, I have little hesitation in now concluding with Mr. Smith that the form of these markings is hexagonal.

In speaking of these curious structures it will be seen that the division of Mr. Smith has been followed; and that the genus *Navicula* of Kützing is divided into *Navicula*, distinguished by the delicacy of the striæ, and their moniliform character; *Pinnularia*, from the striæ, owing to the confluent nature of the cellular structure of its epiderm, having the appearance of distinct costæ; and *Pleurosigma* from the characteristic curve of its beautiful frustules.

* Quekett on the Microscope, 2nd Edit., p. 475.

† Smith, vol. i., pp. 61, 62.

On DEFINING *the* POSITION *and* MEASURING *the* MAGNITUDE *of* MICROSCOPIC OBJECTS. By the Rev. W. HODGSON, M.A., Incumbent of Brathay.

IT is a matter of great practical convenience that the Microscopical Society have adopted, as one of their standards for size, a slide which measures exactly three inches by one. Of the three square inches thus fixed upon, the middle square inch is that which alone is employed to carry the object. The inch on the right hand is appropriated to the label, or name; that on the left may be given up to registering the position of any object, or may be left unoccupied altogether. The middle square inch, therefore, is the only one to which any measurements need refer. Let, then, the bounding lines of this square inch at the bottom and on the left hand be taken as what geometers would call the axes of rectangular co-ordinates, or what, in the language of map-makers and geographers, would be the equator and the first meridian, and let the measurements be made in hundredths of an inch.

If an object, P (fig. 1), upon a slide represented by the *dark* thick lines of the figure, were distant from A C by 67-100ths of an inch, and from A B 39-100ths, a geometer would at once understand its position from the values $x = \cdot 67$ and $y = \cdot 39$, and the geographer would know what situation was intended by long. 67° and lat. 39°.

In order, therefore, to define the place of any object on a slide, two numbers are all that are essential.

The next step is to bring the point thus defined into the centre of the field of the microscope. In all modern microscopes, of even the most moderate pretensions, the optical axis of the instrument will, if produced, pass through the centre of the stage; so that there exists already, in every such microscope, a fixed point for the origin of co-ordinates, or for the intersection of our microscopical equator and first meridian. With the assistance of a diametral cobweb-line in the eye-piece of the microscope, the point A (fig. 1) of the slide, which is situated exactly one inch from its left-hand extremity, may be brought accurately to the centre of the stage, so that A B and C D A coincide respectively with the horizontal and vertical lines through that point. The measurements, therefore, which before were referred only to the middle square inch of the slide, may now, by means of graduation, be transferred to the stage of the microscope, or to a supplementary stage with the name of "a finder."

In the simplest case of a *plain* stage, a piece of sheet brass,

zinc, card, or other material, four inches by two, is prepared with a central hole of one inch in diameter, and fitted, with ledges, pins, springs, or some such contrivance, to the stage of the microscope, in such a condition as to allow the glass slide to be moved over it in various directions without disturbing its position. An empty slide, on which the line A C has been drawn with a common writing diamond, is brought, with the help of the cobweb line in the eye-piece, into the situation shown at fig. 1. The lines H I, H K, which are merely the prolongations of the lines A H, G H given by the edges of the slide, are graduated into tenths and hundredths of an inch, and numbered both ways from H.

In order to bring an object, P, defined by long. 67° and lat. 39°, into the centre of the field, place the slide so that the edge G H cuts the scale H I at the 67th division, while the edge H A cuts the other scale at the 39th division, as shown in fig. 2. It is desirable to have the graduation of H K repeated at L M, as an assistance towards keeping the line A B parallel to its former position. With a plain stage, the above plan is sufficient for those whose eyes can deal readily with hundredths of an inch, and whose fingers can easily make adjustments with the requisite nicety.

When the stage is fitted (as in the Students' Microscopes of Messrs. Smith and Beck) with dove-tailed grooves, in which a frame for steadying the slide moves up and down, the position represented in fig. 1 is obtained with more ease than with a stage entirely plain. There is also a further advantage in this case, by which minute dividing may be dispensed with, without any sacrifice of accuracy. The moveable frame may have attached to it a piece of thin brass, about an inch broad, and on this the graduation H I, fig. 1, may be replaced by a diagonal scale reading to hundredths of an inch, while the edge on the right hand, or in some other convenient position, may carry a vernier, divided as in the common barometer, by which divisions of tenths on the edge of the stage may be read to hundredths, instead of having recourse to such minuteness as is required for the plain stage at H K.

Indeed, minuteness of division may be altogether dispensed with, even for the plain stage, by adopting the form of Indicator represented in fig. 3. The principle involved is precisely the same as that employed in fig. 1, and the only difference in the application of it consists in substituting two diagonal scales reading to hundredths of an inch, for the other smaller and less convenient graduations. The divisions in this case are so large that, with a flat rule and a writing diamond, the lines may be readily drawn in a few minutes upon a piece of

glass of proper size placed over fig. 3: and if the lines across and near the centre are drawn by VERY light touches, so as to be scarcely visible to the unassisted eye, the centreing of the instrument is more easily effected, while no perceptible defect results in the illumination of the object.

More elaborate instruments, possessing movements in horizontal and vertical directions by means of fine screws with micrometer heads, have already the powers requisite for defining the place of an object, when once the commencing position, fig. 1, has been carefully ascertained, and either marked upon the instrument or registered for reference.

The principle, therefore, is simple in its character as well as perfectly general in its application, and supplies the want, which has been expressed, of a "UNIVERSAL INDICATOR" for the microscope.

With reference to the measurement of the magnitude of microscopic objects, I have to suggest a modification of the ingenious and elegant micrometer of Welcker, described in No. XIV. of the Microscopical Journal, by which all graduation is dispensed with, except such as is found upon the ordinary scales supplied with the commonest sets of mathematical instruments, viz., a scale of half-inches divided to tenths and hundredths. By means of cross-lines drawn on the diaphragm of the eye-piece, and with a stage micrometer divided to hundredths and thousandths of an inch, the *radius* of the circle traced out by the intersection of the cross-lines is carefully measured. The positions C D, *c d* (fig. 4), show the method of effecting this; and if it should be found that the radius of the dotted circle does not coincide exactly with some number of thousandths of an inch, this inconvenience may be easily rectified by means of the *draw-tube*. For example, in an instrument which I have recently applied to a Student's Microscope by Messrs. Smith and Beck, the radius of the dotted circle was found to be ·0145 inch very nearly: by drawing out the tube to the extent of 3·4 inches the radius was measured exactly by ·01 inch.

The modification which I propose for the external part of Welcker's instrument consists in substituting a right-angled *triangle* for the circular sector, and suppressing all graduation. A glance at fig. 5 will explain the matter at once. The angle at E is a right angle, and the distance O E is exactly five inches. The method of measuring the object is shown in fig. 6. The object is brought so that one extremity of it is at the intersection of the cross-lines, while the index O F coincides with the line O E on the triangle. By the rotation of the eye-piece, the diametral line is made to touch the other

extremity of the object, as shown by a O b, fig. 6. The index, which is attached to the eye-piece, is by this movement brought into the position O F, and the distance E F, when read by means of the rule with the diagonal scale, gives the dimensions of the microscopic object to three places of figures. Let the distance E F, for example, when measured by the scale, be 3·45 half-inches; this gives at once as the length of the microscopic object ·00345 inch.

When a higher power was applied to the microscope, the radius of the dotted circle was measured exactly by ·004 inch on the stage micrometer; but if the radius is accurately known in thousandths of an inch, there is no difficulty in adapting the method above suggested to this or any other radius. Suppose, for instance, that an object, much smaller than the former, from its being more highly magnified, still appears of the same size as M N, fig. 6, and that the reading given by the scale is as before 3·45 half-inches, then the length of the object will be, not ·00345 inch, but a quantity bearing the same proportion to it that 4 does to 10: nothing more, therefore, is requisite than to add a cipher to the left and multiply the result by 4: thus ·000345 inch × 4 = ·000138 inch, which is the length of the object.

For those who prefer greater accuracy and more expensively-divided instruments, the plan of measuring by the tangent is more easy in manipulation, and the trigonometrical calculation is more simple, than when the chord is employed. The equation,

$$\text{log. M N} = \text{log. O M} + \text{log. tan. M O N},$$

gives all that is necessary at once; and if the radius O M be unity, it is sufficient to find the number corresponding to the log. tan. of the degrees and minutes, &c. of any observed angle.

In the case chosen above, the angle M O N was taken to be 19°, of which the log. tan. = 9·536972, and the number corresponding with this gives, for the length of M N,

with the lower power, ·034432
and with the higher, ·00137728.

The error, therefore, by the plan now proposed, is less than one ten-thousandth part of an inch in the one case, and less than one hundredth-thousandth in the other. The triangle can be made of wood, brass, zinc, card-board, or any other suitable material, and is recommended on the score of cheapness, portability, facility in use, and accuracy of result.

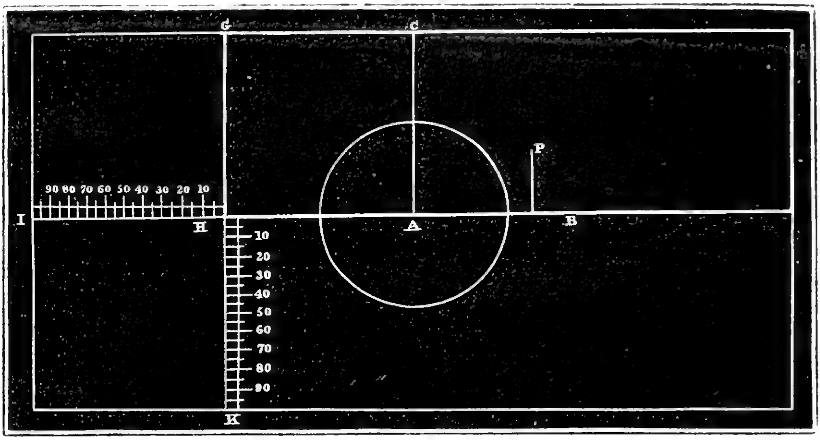


Fig. 1.

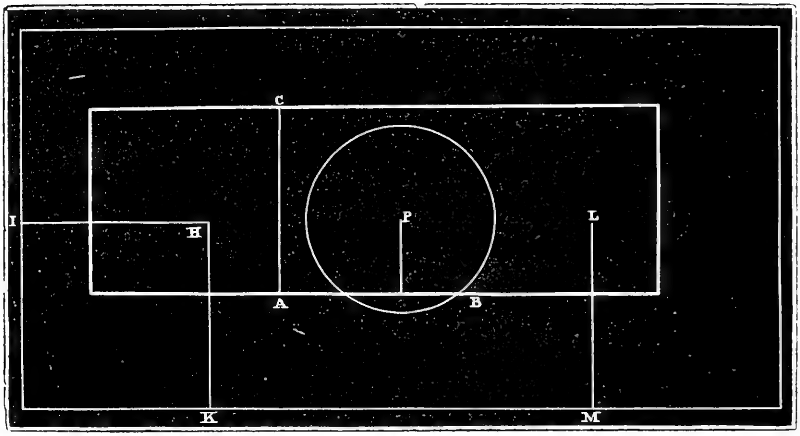


Fig. 2.

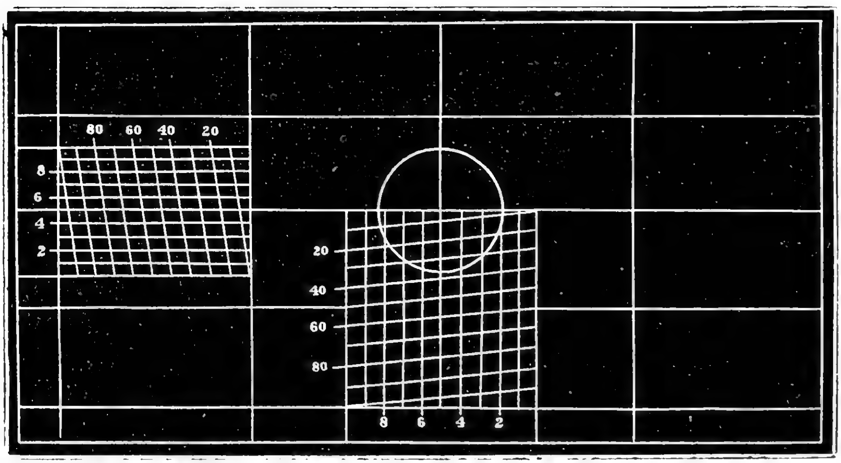


Fig. 3.

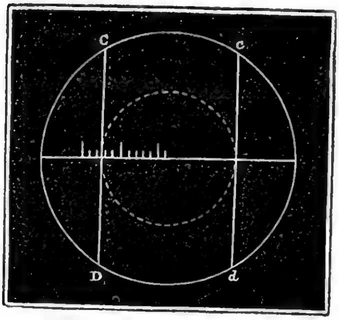


Fig. 4.

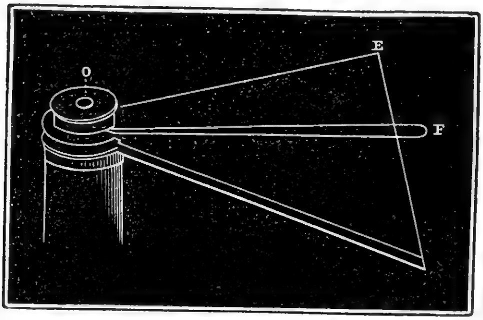


Fig. 5.

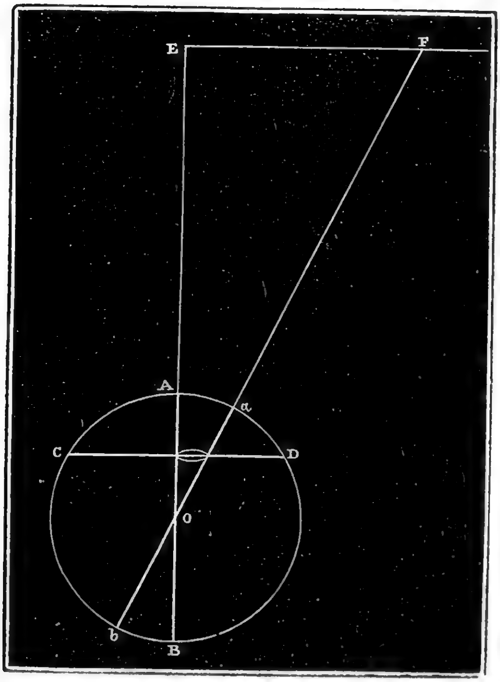


Fig. 6.

On the DEVELOPMENT *of the* ENAMEL. By JOHN TOMES, F.R.S., Surgeon-Dentist to the Middlesex Hospital.

(*Continued from page* 104.)

BEFORE proceeding with this article, which was commenced in the last Number of the Journal, I must take the opportunity afforded by the publication of the second part to correct certain typographical errors which have crept into the last pages of the first. The first error is somewhat important, as it makes me contradict a previous statement. At page 102, and in the ninth line, *not* is left out after the word *contracted;* and in the tenth line after the word dentine, *or* has been substituted for *but.* At the fifth line from the bottom of the page, *alteratives* has been substituted for *alterations.* In page 103, at the twentieth line from the bottom of the page, the word *sockets* has been printed instead of *sections;* in the eleventh *fitted* for *filled;* in the seventh *meshes* for *masses;* and in the fifth line from the bottom of the page, *fibrilea* for *fibrillæ.* In page 104, *distant* will be found instead of *distinct* in the eighteenth line from the bottom of the page.

The latter part of the preceding paper referred to the structure of the enamel when fully formed. It is proposed in this communication to enter upon the manner of formation.

Mr. Huxley, in an able article published in this Journal (No. III., 1853), entered very fully into the history of the subject, giving a clear account of the different views which have been promulgated, and citing the authorities for each. Under these circumstances it will not be necessary for me to go over the same ground. I will, therefore, refer the reader to the pages which contain Mr. Huxley's paper, in place of reprinting his historical matter.*

After adopting this arrangement, that part of Mr. Huxley's paper which gives his own views on the development of the enamel, together with that which has been subsequeutly written upon the same subject, alone remains for consideration.

Prior to the appearance of Mr. Huxley's essay, it was pretty generally believed that the enamel fibres were formed by the direct calcification of the columns of the enamel organ. This opinion has, however, been shaken by a discovery made by that distinguished physiologist. He found

* On the Development of the Teeth, and on the Nature and Import of Nasmyth's 'Persistent Capsule;' by Thomas H. Huxley, F.R.S.—'Quarterly Journal of Microscopical Science,' No. III., 1853.

that a membrane can be raised from the surface of the enamel, at any period during growth, by the addition of an acid; the membrane being external to the enamel fibres already formed, and internal to the enamel organ—in fact, lying between and separating the two tissues. This membrane Mr. Huxley regards as the *membrana preformativa* of authors. He describes it as perfectly clear and transparent, and as being continued over the dentine in those parts where enamel has not been formed, and over the dentinal pulp where dentine has yet to be developed, giving it in fact the position which the basement membrane of the mucous membrane of the mouth would occupy when the tooth-pulp is in the follicular stage, and consequently in the sacular stage, supposing such membrane to exist in the one case, and that it has not disappeared in the other. These points are shown in the figures illustrating Mr. Huxley's paper.

M. Lent, a pupil of Kölliker's, published a paper on the development of the dental tissues, which was subjected to the Professor for revision.* Hence it must be regarded as expressing to some extent the opinions of M. Kölliker as well as those of M. Lent. The account there given of the development of the enamel is in the main but a confirmation of Mr. Huxley's statements, the points of difference being unimportant. M. Lent describes the so-called *membrana preformativa* as structureless, but as it were indented with the ends of the enamel fibres. His figure shows a surface impressed with minute square depressions. Mr. Huxley gives a similar figure. The latter author says: "Neither the capsule nor the enamel organ take any direct share in the development of the dental tissues, all three of which—viz., enamel, dentine, and cement—are formed beneath the *membrana preformativa*, or basement membrane of the pulp." In another place he says: "Neither the capsule nor the 'enamel organ,' which consist of the epithelium of both the papilla and the capsule, contribute *directly* in any way to the development of the dental tissues, though they may indirectly."

M. Lent believes that the enamel organ exerts some direct influence in the formation of the enamel, and puts forward the following hypothesis, viz., that the cells of the enamel organ secrete a fluid, which passes through the *membrana preformativa* and there forms enamel, and he assumes that the secretions of individual cells are independent, each one forming or corresponding to an enamel fibre.

* 'Ueber die Entwicklung des Zahnbeins und des Schmelzes,' von Eduard Lent, Stud. Med. aus Hamm.' 'Zeitschrift für Wissenschaftlichs Zoologie Sechster Band,' p. 121, 1855.

I have latterly been occupied with this subject, but have for the most part confined my investigation to young and fœtal teeth of the human subject. I must, therefore, be understood to speak of the enamel of human teeth.

The method of investigation has been that indicated by Mr. Huxley and M. Lent; and in the pursuit of the subject I have endeavoured to trace the development of the tissue without reference to its homological relations, under the belief that the structure and development of a tissue should be perfectly understood before assigning its place among other structures.

The investigations were commenced upon the lower jaw of a nine-months' fœtus, which had been in spirit for some weeks. On placing an incisor under the microscope, the surface was seen to be covered by the enamel organ: the addition of a drop of dilute hydrochloric acid (one part of acid to eleven of water) at once produced the appearance described and figured by Mr. Huxley; that is, a membrane seemed by degrees to swell up from the whole surface of the enamel, the outer surface having adherent to it, by their proximal ends, the columns of the enamel organ. The covering glass was then removed, the acid taken up with blotting-paper, and dilute spirits of wine substituted. The next step in the investigation was the removal of the membrane raised by the acid, in order to submit it to separate examination. This end was effected by the aid of needles; but in the operation the part became torn in several places, so that its sac-like form was lost. On returning the specimen to the microscope it was seen that the membrane had a strong tendency to roll up in an opposite direction to its normal position on the tooth, the outside thereby becoming the inside of the rolls. This disposition offered facilities for examination: had it been otherwise there would have been some difficulty in obtaining a good view of the torn edge—an inspection of which, with the quarter of an inch object-glass, showed the conditions given in fig. 1, Pl. XV. It will be observed, on examining this figure (which is an accurate representation of a preparation which I have succeeded in preserving), that we have on the concave side the columns of the enamel organ, while on the convex side the decalcified enamel fibres remain. I have failed to discover anything like a distinct membrane interposed between the two parts. A point may be recognised where the two graduate into each other; but this part cannot be re garded as a membrane, as the forming-enamel fibres clearly pass through it.

The columns of the enamel organ are, however, very readily

detached, and many float off in the fluid when the part is under manipulation. If examined in this condition, some are found in parallel bundles, and apparently attached slightly to each other; but many are quite unconnected (fig. 2). But whether associated or single, each column will be found to have a delicate small process projecting from that extremity which was connected with the enamel, a process which would pass through a membrana preformativa could such be shown to exist. Immediately above the point from which the process starts, the column has, when separated from its fellows, a slight circumferential dilatation, as though the cylinder had been everted at the edge when the separation was effected. A close examination of the columns will, I think, lead to the belief that each is composed of a delicate sheath, in which is enclosed one or more nuclei, the interspaces being occupied by transparent granular matter. The nuclei are usually more distinct near the peripheral end of the columns; the attached extremity being commonly more granular than nucleated; but I have seen cases in which the sheath seemed pretty fully occupied by nuclei. After the preparation had been kept for a few weeks, the nuclei became more faint, and the granular matter more apparent.

Now, supposing the decalcified enamel fibres are detached from the columns and are viewed singly, it will be seen that the end which approached the dentine is clear and transparent, while that which meets the columns is coarse and granular, appearing by transmitted light of a deep-brown colour; indeed, but for the colour, it would be difficult to distinguish the distal extremity of the decalcified enamel fibre from the proximal end of the column of the enamel organ, fig. 3.

In many parts of the specimen the columns have been wholly detached, leaving a surface similar to that figured by Mr. Huxley, and described as the membrana preformativa. But if we look directly at the edge of the specimen where it is turned towards the observer, it will be seen that the enamel fibres pass through to the surface of this apparent membrane, fig. 4, *a*.

The enamel fibre, in its decalcified state, consists of a fine transparent and structureless sheath in the part which is fully formed, but in the distal portions, where development is progressing, the sheath appears to contain in many instances granular matter, fig. 3.

M. Lent mentions that he had at first some difficulty in obtaining the membrana preformativa, freed from enamel fibres. He at length succeeded, by treating the decalcified specimens with caustic potash or soda. No doubt the ex-

tremely delicate sheath of the enamel fibre would under such treatment soon disappear, and he might have got rid of the so-called membrane by a continued application of the same agent, in which case he might as fairly have argued that no soft tissue existed, as he has done in assuming that a distinct membrane bounds the enamel fibres because the sheaths have been dissolved by an alkali, before the partly-ossified distal extremities disappeared.*

The appearances which I have described, as existing in one specimen, may be found in the teeth of similar age in any fœtus, which has not been too long kept. Immersion in spirits of wine for a short time, I think, favours the demonstration, as the extremely-delicate columns of the enamel organ become hardened, and hence keep their normal position more frequently, than in perfectly-fresh subjects. Still in the latter similar structural conditions to those I have described may be observed.

If, instead of taking an incisor, the first molar of a nine-months' fœtus be selected, the tooth-sac will be found distended with a fluid, in which numerous nucleated cells float. Generally the cusps of the pulp are covered by caps of dentine, though this is not uniformly the case at this age. In several instances I have preserved specimens, in which one cusp only was invested with dentine, while the others were quite free from calcification. In the latter case the membrana preformativa should be distinctly visible. I have not been able, however, to see anything that conveys to my mind the idea of a distinct and separable membrane. A slight amount of transparent tissue may be seen extending beyond the peripheral dentinal cells, but it also dips in between them, and has all the appearance of being nothing more than the blas-

* The results of the following experiment illustrate the amount of dependence which can be placed upon membranes, the existence of which cannot be demonstrated otherwise than by the use of reagents. A thin longitudinal section was prepared from the upper incisor of a rat. This was placed for a short time in hydrochloric acid and water (one part of acid to eleven parts of water); on removal, the acid was neutralized by a solution of potash. When placed in the field of the microscope, it was seen that membranes had started up from the whole surface of the preparation. Not only did a membrane part from the surface of the enamel, but one equally distinct peeled up from the worn, masticating surface of the tooth, while others appeared upon the surfaces which were produced in grinding the section. The membranes thus demonstrated were distinct, clear, and transparent, but exhibited no trace of the structural characters of the tissues from which they were derived, and of which they had formed a part prior to the application of the reagents. In this experiment, the action of the acid was arrested by the potash before the whole of the section had been decalcified. The edges and surfaces were softened, but the interior remained firm and retained its structural characters.

tema, which connects into a mass the cells of the pulp. I do not, however, propose to go into the development of dentine in the present article; hence the question of the presence or absence of a preformative membrane extending over the dentinal pulp, and the relations of such membrane to the development of dentine, may be left for future discussion.

If attention be directed to the cusps in which calcification has commenced, appearances similar to those described in the incisor will, if similarly treated, be found, excepting only the enamel organ, the columns of which, in this case, are shorter than those in the more advanced tooth.

Although I have confined the description to the structural conditions found in developing teeth in one jaw, my examinations have been extended over the teeth from many fœtal jaws. The results have, however, been uniformly similar.

Assuming that the foregoing observations have been correctly made, we need have no difficulty in explaining the manner in which the enamel is developed, and in accounting for the appearances exhibited in the fully-formed tissue; of which a description and figures were given in the last Number of this Journal. The columns of the enamel organ must be regarded as subservient to the development of the fibres, the conversion of the one into the other taking place in the following manner:—The proximal end of the column becomes calcified, not uniformly throughout its thickness, but the outer surface or sheath first receives the salts of lime, and at the same time the columns become united laterally. At this point—that is, at the extreme margin of calcification—the columns readily separate from the fibres, and leave a surface which, when looked upon directly, has the appearance of a membrane, the reticulate character of which (figs. 4 and 5) is due to the withdrawal of the central portion of the calcifying column, this central portion being the process which has been described as forming part of the detached column (fig. 2). The calcification of the central part of the column goes on gradually, but does not keep pace with that of the sheath, and when calcified, presents some points of difference when compared with the surface of fibre. Thus, in adult tissue, the interior of the fibre dissolved before the surface, leaving the reticulated appearance described and figured in the last Number of the Journal. Before calcification, the nuclei of the column appear to break up into subgranular matter, which may often be detected at the distal ends of the forming-enamel fibres (fig. 3). The situation usually occupied by well-marked oval nuclei is the distal extremities of the enamel-organ columns; but sometimes we find examples in

which the nuclei, or bodies very like them, fill up the whole of the sheath, and become calcified: fig. 6 illustrates this condition. It may generally be found in the opaque white or brown teeth frequently seen in strumous subjects. A little practice will enable the histologist to recognize teeth which will yield specimens like the one figured.

Many authors have noticed the transverse striation of the enamel fibres. The structural condition I have described is but a more-perfect development of that which is but faintly marked in the striation, and a less-perfect development of the enamel itself.

In looking over a series of sections of teeth, we shall not fail to find other exceptional conditions than that I have described, and these must be also regarded as the results of imperfect development. I allude to the irregularly-granular state of the enamel fibres found in patches scattered here and there amongst highly-developed tissue. At such points the granularity is in many specimens confined to the interior of the fibre, the sheath appearing clear and structureless. Indeed, this deviation from the normal state appears due to the calcification of the columns of the enamel organ, prior to that change by which the granularity disappears, and the fibre becomes transparent.

Mr. Huxley has referred to the "persistent capsule" described by Mr. Nasmyth, and considers it to be identical with the *membrana preformativa*. In several specimens which have been decalcified, after being reduced sufficiently thin for microscopic examination, this membrane is obviously continuous with the cementum of the fang, and in other specimens, which have not been treated with acid, I find the membrane thickened in the deep depression of the crown of molar teeth, and there tenanted by a distinct lacuna. The occurrence of these two circumstances would indicate that Nasmyth's membrane is cementum, rather than membrana preformativa. The general absence of lacuna in this membrane is due to its want of sufficient thickness to contain them, just as we find these bodies wanting in the cementum of the fang when the layer of that tissue is very thin.

Apart, however, from this apparently-structureless layer described by Mr. Nasmyth, we may sometimes observe a diminution in the fibrous character of the enamel at the terminations of the fibres on the surface of the tooth, and also at the terminal edge of the enamel on the neck of the tooth. In each of these situations appearances may be found which suggest the idea that a fluid blastema became calcified, and that the fibres had in the process become fused, and more or

less lost in the mass so formed. Indeed, in the situation last mentioned, lamination of an indistinct character may take the place of fibres; or both the laminated and fibrous arrangement may be replaced by a structure exhibiting little arrangement of parts. In any case, however, this deviation from the normal structural character of enamel is limited to the terminal edge of the tissue. The development of dentine and cement will form the subject of a future communication.

Contributions to Micro-Mineralogy. By Samuel Highley, F.G.S., F.C.S., &c.

Introduction.

In 1847, not finding any classification of Minerals whereby to arrange my collection, that satisfied my mind, I laid the scheme of a Mineral-System founded on the chemical crystallographic and physical characters according to their relative value, and which I conceived threw the species into more natural groups than any of the Systems I was then acquainted with, all being either too chemical or too physical in their arrangements to meet the requirements of a Natural History method, where *all* the characters must receive their due share of consideration.

My scheme was based upon the isomorphous relations of the electro-negative to the electro-positive elements, and approached more the since-published Systems of Nordenskiöld,* (which I did not become acquainted with till 1851, when that author visited the Great Exhibition), Dana† and Rose.‡ This I showed at the time to several eminent chemists and naturalists, who advised me to publish it as a Synopsis, which I determined on and announced (and which I trust will be produced ere long); but the more I advanced the more I became assured that a searching analytical inquiry must be instituted in various departments of Mineralogical Science before anything approaching a philosophical or logical distribution of inorganic bodies could be hoped for. Among other things, heterogeneous masses of mineral matter, mineralized plants and animals, &c., have, *for convenience*, been classed as true species under the mineralizing constituent.

* *Ueber Das Atomistisch-Chemische Mineral System, &c., von Nils Nordenskiöld, Helsingfors,* 1849.

† System—*Chemical Classification, edition of* 1850.

‡ Das Krystallo-Chemische Mineral System, von Gustav Rose, Leipzig, 1852.

An example of this may be found in the pages of this Journal,* in the vexed question of the Torbane-hill Mineral, and the Microscope as an instrument of structural, physical, micro-chemical, and crystallological research may help to solve many more such problems in mineralogy.

For the last three years my time has been fully occupied with other matters, but now that I again find leisure, I return to these inquiries; and in the pages of this Journal I propose to publish from time to time such investigations as bear upon the microscopical part of the subject, and which I think will well repay the labour, for though the bibliography of microscopy abounds with papers and works on Animal and Vegetable Structure, I am surprised to find how very few have been written on mineral or inorganized bodies.

The Mineral Kingdom must embrace a wider domain than that originally set apart for it, before it can be studied with advantage; not only must it include those aggregates of minerals and mineralized masses which are now regarded as a distinct branch of study under the term Petralogy, or which are included with Geology, but also the so-called artificial products of the laboratory and the smelting furnace; for where exists the difference between the crystallogenic forces that produce the CYANOSE of the mines and the Sulphate of Copper of our laboratory capsules? How should we know that Sulphur is dimorphous without resort to the crucible? or that iodides, bromides, chlorides, and fluorides form isomorphous groups if we did not take cognizance of laboratory products? As well might modern Botanists and Zoologists ignore the extinct forms of former epochs wherewith they now fill up many a gap in their Systems. If Mineralogy has of late years been drifting too much from its position as a branch of Natural History, out of the hands of the Naturalist into those of the Chemist,† advantage has arisen, inasmuch as Rammelsberg and Schabus have examined a large class of laboratory products more in accordance with the Natural History method—the results they have recently given to the world in two valuable publications.‡

From this point of view, then, the study of the Mineral

* See Quekett, TRANSACTIONS, vol. ii., p. 34, Pl. III., IV., V., Highley, JOURNAL, vol. ii., p. 141. 'Is Coal a Mineralogical Species?'—Redfern, vol. iii., p. 106, Pl. VII., VIII., IX.

† The British Association does not include Mineralogy in the Natural History or Geological Sections, but in the Chemical Section; this indicates the point of view from which this science is regarded in England.

‡ Handbuch der Krystallographischen Chemie von C. F. Rammelsberg, Berlin, 1855; and Bestimmung der Krystallgestalten in Chemischen Laboratorien Producte, von Jacob Schabus, Vienna, 1855.

Kingdom should embrace the physiography and classification of *all* inorganized bodies; and although the sphere of inquiry would be thus greatly extended beyond the limits originally comprehended under the term MINERALOGY, yet that term might be retained with a conventional significance implying *the Natural History Method of inquiry*, which embraces a consideration of *all the characters* common to inorganic bodies, in contradistinction to *the strictly Chemical Method*. In this conventional use of the term Mineralogy for a wider sphere of inquiry, I am supported (though from another point of view) by Professor Fleming of Edinburgh.*

The Mineral Kingdom would then be naturally divided into two broad and great divisions, viz.:—

I. HOMOGENIA, embracing Minerals proper, and

II. HETEROGENIA, including bodies of definite chemical composition, but of composite structure—as Coal, Bergmehl, &c.—Mechanical mixtures of chemical constituents, but of apparent homogeneous aspect, as Obsidian—and Erupted, Sedimentary, Metamorphosed, Conglomerated † aggregates of mineral matter, comprising Rocks proper.

And here it may be necessary to define my idea of *the Mineral Individual.* This, as most Mineralogists are agreed, is the crystal state, which implies a definite chemical composition in the constituting mass. But we have other *forms* of matter to deal with, which must find a place in our Systems: these are the amorphous, liquid and vaporiform conditions of the same chemical body; which states I regard, for convenience of description, if not for more logical reasons, as analogous to the metamorphic or embryonic stages of the lower forms of animals; and as Zoologists now regard the whole cycle of Metamorphism or Development to be necessarily comprised in the description of *the Animal Individual*, so do I conceive the vaporiform, liquid, and amorphous states of the same body, as only requiring favourable conditions to be developed into the perfect form or crystal state, to represent the series of *the Mineral Individual.* Thus, steam by condensation passes into water; water, at a certain temperature, passes into the amorphous or crystal state according to circumstances; in the latter case it is HEXAGONAL ICE—*the perfect Mineral Individual* of the series. This, perhaps, is

* On the different Branches of Natural History, &c.; an Address to the Natural History Section of the British Association at Glasgow, 1855: Edinburgh New Phil. Journal, No. 5, New Series, pp. 130–2.

† *Vide* Humboldt's Cosmos, by Sabine, vol. i., p. 236.

better than regarding these different states, as some authors have done, as grounds for *Specific* distinctions.

As crystallization gives individuality to the Mineral mass, the Crystal System should be the ground for determining Specific distinctions.

From considerations of the allotropic condition of matter in dimorphous bodies, probably each crystal form has an amorphous state of its constituent peculiar to itself. Thus Rhombic Sulphur is produced from solution at low temperature, and has an amorphous state common to it at ordinary temperatures. Monoclinic Sulphur, on the other hand, exists only at high temperatures, and there is an allotropic amorphous state of sulphur that, likewise, exists only at high temperatures.

Ordinary honey-coloured amorphous Phosphorus produces from solution Rhombic Dodecahedrons; probably the black amorphous phosphorus would produce, under favouring circumstances, crystals belonging to a different system. Several other instances might be cited, but it would be out of place to enter further on this part of the subject in the pages of this Journal, and I therefore proceed to the consideration of the objects more specially in view.

It is my intention to consider the subjects of these contributions under the following heads or parts :—

1st. The Instruments of Micro-Mineralogical research.

2nd. Micro-Crystallography.—Under this head I purport describing crystal forms as seen in the field of the Microscope,—Goniometry.—The means of determining true forms from apparent forms, caused by optical and other deceptions. The Crystal-Systems under which microscopical crystals may be classed. The relation of Polarized light to the different Crystal-Systems, and the method of measuring the angles of the optic axes, diameter of the rings, and amount of rotation, &c. in depolarizing crystals and inorganic bodies, and the method of determining the Crystal-System to which a crystal belongs, by means of Kobell's Stauroscope. The relation that exists between the symmetrical grouping of crystals and the Crystal-System to which they belong;* and here a new field for inquiry is open. In Vol. III. of this Journal, Plates XIII. XIV., are figured many very beautiful groupings

* I drew attention to this subject in No. I. of 'The Chemist,' New Series, p. 58; 1853.

of Snow Crystals, throughout all of which Hexagonal Symmetry prevails. I would draw especial attention to fig. 14, a combination of obtuse Rhombohedrons, with a central Hexagonal Prism: the relation of the forms, and the symmetry of the grouping, is in strict accordance with the Crystal-System to which Ice belongs, viz., the Hexagonal or Rhombohedric. These symmetrical groups have been classed as twin-crystals, a category to which I fancy, on a broader view of the subject, they will be found not to belong.

3rd. MICRO-CRYSTALLOGENY, comprising the influence of foreign bodies, light, heat, electricity, magnetism, &c., on crystallization as viewed in the field of the Microscope.

4th. MICRO-ANALYSIS, comprising methods of Structural, Chemical, and Physical examination of inorganic bodies, where the microscope *is necessary as an aid to the eye;* under this head will be given the method of determining the Indices of Refraction in minute prisms, &c.

5th. MICRO-MINERALOGY. In this section will be given a systematic Microscopical examination of mineral bodies, from the simplest to those of the most complex chemical composition, for the purpose of separating from the true mineral Species, those that are of heterogeneous structure, and belong more strictly to the nature of rocks. The following divisions suggests themselves:

Division—HETEROGENIA.

(*Groups determined by Micro-Analysis.*)

OF DEFINITE CHEMICAL COMPOSITION.

A.—Composed of two or more varieties of the same Species, or allied Species associated in bands, concentric layers, &c., of which many AGATES are a type.

B.—Homogeneous in aspect to the unaided eye, but composed in mass of vegetable remains saturated with mineral matter, of which COAL is a Type; or conglomerated by mineral matter; or consisting of the inorganic hard parts of vegetables condensed into rock-like masses; this group might be termed PHYTOLITES.

C.—PHYTO-ZOOLITES, an intermediate group between this and the next, the organized constituents being a mixture of vegetables and animal remains, of which BERGMEHL is a Type.

D.—ZOOLITES, the organized constituents being animal remains entirely, of which CHALK is a Type.

[*Part I. will appear in our next.*]

REVIEWS.

RUDIMENTS OF PATHOLOGICAL HISTOLOGY. By CARL WEDL, M.D., &c. Translated and Edited by GEORGE BUSK, F.R.S. (Printed for the Sydenham Society.)

THE Sydenham Society has done unspeakable service for the medical profession by presenting its members with numerous works on Anatomy, Physiology, Medicine and Surgery, in an English form, which, but for it, would ever have remained in this country sealed books, unread and perhaps unknown to the vast majority.

One of the great defects, we might almost call it an inevitable defect, in medical education, is its partialness—its one-sidedness. The large amount of scientific study necessary in medical education, the few years allotted to learning, and the early age at which most young medical men are compelled, from circumstances, to spend their whole time in the practice of their profession, preclude almost the possibility of anything like a complete general education, and but a small proportion of the members of the profession will be found well conversant with some of the languages of Europe in which many of the most important works of the present day are written. These observations are especially applicable to the German language—and in the German tongue have appeared recently many of the most important publications that have ever been issued upon subjects connected with the medical profession.

Not the least valuable of these is the work now before us.

The title of Wedl's work—'Rudiments of Pathological Histology,' is not absolutely correct, and does not do full justice to its real character. It is not *rudimentary;* for the subjects of which it treats are well considered in all their length and breadth; and although histological descriptions constitute the bulk of the letter-press, and the great majority of the illustrations refer to structures as seen with high magnifying powers, still there are interspersed many admirable descriptions of coarse pathological anatomy, and much interesting generalization; and among the figures are many illustrative of structures as seen by unaided vision.

Again, the work has not the completeness which its general and comprehensive title would seem to imply: the literature of the several subjects treated of is very imperfect, and indeed no effort seems to have been made on the part of the author to render it otherwise: that was evidently not his object.

What Wedl's work truly is, and what it might, in a somewhat lengthy title, be styled, is—*The records of the labours of a single individual in Pathological Anatomy in which Histology has been chiefly considered.* In this circumstance lies the great value of Wedl's book—its originality: he has observed for himself, described for himself, thought for himself, and, what is of no small importance, he has illustrated for himself. Thus it is that his observations have a circumstantial importance, and his faithful records become a truthful authority, so valuable for future reference. The general scope of the work may be best described in the Author's own words—

"The plan followed in the work has been the giving, in the first place, as a methodical foundation, general morphological views and theories of development with respect to *exudations*, *atrophy*, *hypertrophy*, the *formation* of *inorganic* and of *organic* substances, and particularly of new-formed elementary organs and their various combinations.

"In the special part the subjects treated of are arranged in families: I. Inorganic formations; II. Atrophies; III. Hypertrophies; IV. Exudations; V. New formations; VI. Parasites."

Mr. Busk, in his translation, has omitted, and we think very judiciously, all notice of the Chapter on Parasites, which really have nothing to do with pathology.

It is not our purpose to dwell farther upon Dr. Wedl's labours; and we will only add that we entirely agree with his translator's remark, that—"the extent of original information and original illustration in his work will always entitle it to a high place."

On the manner in which Mr. Busk has fulfilled his task of translating and editing this volume we need scarcely remark. We have not only to thank him for an agreeable and facile translation of the original text, but for many valuable annotations in the form of foot-notes, for a voluminous index, and a copious table of 'contents' appended to the volume. There is, however, one point in which, we think, he has not used his editorial functions with his usual judgment: he remarks at the end of his preface—"The descriptions of the figures, usually placed at the bottom of the page, are here given together at the end of the book—an arrangement which it is hoped will be found convenient for reference." We really do not see in what this is more convenient than the old method; indeed *we* have found it decidedly inconvenient, and we should have preferred casting our eyes from the figure to the bottom of the same page, for the description, to the somewhat tedious process of referring backwards and forwards over some hundreds of pages for the same purpose.

We fear, however, that we may be accused of hypercriticism in noticing this trivial objection amid such general excellence.

Here we should close our brief notice of this work, but there is one passage in the translator's preface which we cannot pass without reference: we allude to the observations he makes on the *cell theory of tissue-development*, and in which we most heartily concur. Mr. Busk remarks—

"The almost blind obedience at present paid to the doctrines of Schwann and Schleiden has apparently acted for some time as a damper upon original thought on the subject. Attention, however, having of late been directed, more particularly by Mr. Huxley, to the foundation upon which this doctrine is based, and to the many and weighty objections to which it is obnoxious, will, it is to be hoped, awaken a more scrutinising and independent spirit of inquiry; when, and not till when, we may hope to see general, and with it Pathological Histology, placed on a firm basis."

We are only too glad to endorse the opinions here implied, and to express our surprise that clear-sighted and conscientious observers can be found who still defend the old cell-development theory absolute and unqualified.

THE MICROGRAPHIC DICTIONARY; A GUIDE TO THE EXAMINATION AND INVESTIGATION OF THE STRUCTURE AND NATURE OF MICROSCOPIC OBJECTS. By J. W. GRIFFITH, M.D., &c., and A. HENFREY, F.R.S., &c. London. Van Voorst, 1856; pp. 696; with 41 Plates by Tuffen West, and numerous Woodcuts.

WE congratulate our readers upon the completion of this laborious and valuable work, whose peculiar nature renders a notice of it in our pages almost imperative. Anything like a critical review, however, of such an extensive encyclopedic volume is obviously impossible within our necessarily confined limits. Nor, perhaps, since the work has been, in part at any rate, long before the public, is such a review now demanded. But we think it incumbent upon us to point out in brief terms what we conceive to be its more striking merits and demerits, and how nearly its execution corresponds with the conception implied in its title; and to what extent it will prove specially useful to the general microscopic observer, for whom alone we take it to be intended.

The Authors state that it is "offered as an index to our knowledge of the structure and properties of bodies revealed by the microscope." This sentence may be taken to mean, either that the work is intended to represent an index of what is known respecting the microscopic structure and (microscopic) properties of all bodies, or of what we know respecting the structure and properties of all microscopic bodies. In neither sense, however, it is clear, does it come up to this ambitious aim. Such a field is too vast to be occupied by any single work of many times the dimensions of

the 'Micrographic Dictionary,' and too varied to be satisfactorily cultivated by one or two individuals, however well qualified. We find no fault, therefore, with the work in that it has fallen short of the promise above quoted, but we may be allowed to express some regret that the object expressed in the title of the book has not been more closely adhered to.

A very useful and interesting work would be one including plain and succinct accounts of the usual objects belonging either to the organic or inorganic world, of a size so minute as to require the aid of the microscope for their correct examination—of objects which come under the observation, not so much of the natural philosopher only, as of the general class of observers who employ the microscope as much as a means of intellectual and instructive amusement and occupation as for the more serious purposes of study. The real student will resort to other sources of instruction than the pages of a Dictionary; and we fear that, notwithstanding its many excellences, the general microscopist, as he may be termed, will find much redundant matter in the present work not very useful to him, and will look in vain for many things which, as we conceive, he would have a right to expect in its pages.

The introductory observations on the "use of the microscope and the examination of microscopic objects," refer chiefly to the construction and mode of using the instrument and to the methods commonly employed in microscopic manipulation. In these, we observe nothing novel or calling for remark, except, perhaps, an implied recommendation to microscopists to use glass slides measuring $2\frac{1}{2} \times 1$ inch instead of those of the now universally adopted dimensions of 3×1 inch. This "mischievous recommendation," as a zealous correspondent terms it, we hope no one will inconvenience himself and others by following. Besides these introductory chapters, the work consists of short notices of various objects taken, apparently, in some measure at random from the animal, vegetable, and mineral kingdoms.

The main bulk of the Dictionary consists of botanical articles. These include a great range of subjects, though chiefly having reference to the lower cryptogamic plants, and they include a considerable amount of valuable and original information. The principal fault we have to find with this department of the work is its very needless bulk, which is caused by the admission of numerous things of no use or interest whatever to the microscopical observer, nor, in fact, to any one, and which seem to be quite out of place where they are found. As a sort of imperfect "Conspectus

Generum" of cryptogamic plants, these articles may have a certain value to the botanist, who will most probably, however, seek his information elsewhere; and of what use, we may ask, to the physiologist or histologist, or to the general microscopic observer, are such notices as these?—"*Drepanophylleæ*, a family of acrocarpous Mosses; containing one East Indian genus, *Drepanophyllum*, Rich., imperfectly known;" or, "*Dryostachium*, J. Sm., a genus of *Polypodieæ*, with very much branched, anastomosing veins, with free branches in the meshes;" or, "*Fadyenia*, Hook., a genus of *Nephrodieæ* (polypodæous Ferns); exotic."—Of which hundreds might be extracted. In general, however, the botanical articles appear to have been judiciously selected, and the descriptions are clear, correct, and well illustrated.

The articles having reference to the animal kingdom, much fewer in number, also include a great amount of matter which seems to us nearly useless where it is given. Surely matters more interesting to those for whom the Micrographic Dictionary is especially adapted might have been selected than those taken from Kölliker's 'Microscopic Anatomy of the Human Body,' with the large and well-known woodcuts given in that work. What, again, is the use of occupying two whole pages with an antiquated tabular view of the animal kingdom, in which, by the way, we observe that the Dugong is parted from its old congeners, the Cetacea, and placed among the Pachydermata, whilst the Shrew (*Sorex*) is made to forget its Insectivorous relatives, and figure among the Rodents? Its hair alone, to adopt a microscopic test, would show that it was an intruder there. The *Polyzoa* (*Bryozoa*) still range with the *Polypi*, and numerous microscopic creatures find no place at all in the list. Of what service, also, are such notices as those of *Calia*, *Caligus*, *Caryophyllæus*, Caseine, *Cecrops*, *Filaria*, Platinum, Chemistry, and many others, which occupy so needlessly much valuable space? Other matters, as, for instance, "Polarized light," of great interest to the microscopist, and upon which he is sure to demand information, are treated in the most cursory way. The article on that subject conveys no information whatever, and yet it might have been made, in a short space, both interesting and useful. The execution, moreover, of several articles more fully given is by no means what it might be. As an instance of the extent to which the confusion of totally distinct things under one term may be carried, we would cite the article "*Polypi*," which contains nearly as many errors as lines. Under the head of *Grantia* no mention is made of Mr. Bowerbank's interesting and

important discovery of the seat and nature of the ciliary action so manifest in that sponge. The notice of Sponge, again, is very imperfect, and in the description of the figures the bases of the sponge spicules are termed the apices, and *vice versâ*. In the Acalephæ the arms, tentacles, &c., are stated to be covered with cilia, and the class generally is said, without any hesitation, to be furnished with a distinct nervous system, and with blood-vessels containing coloured blood, distinct from the chylaqueous channels, although under the head of "chylaqueous system," Dr. Williams's assertion is adopted, that a separate blood vascular system is not found in any form, even in the most rudimentary, below the *Echinodermata*, and the *Acalephæ* are particularly noticed as not possessing one. The omissions, however, in this department of the dictionary are of still greater importance. We look in vain for the words *Bryozoa* or *Polyzoa*, a class of animals wholly microscopic, and containing forms of the greatest variety, beauty, and interest, abounding in the sea and in fresh waters, and together with the equally neglected Sertulariadans, the constant objects of never-ending, pleasing observation to the young and old microscopist.

If half the botanical articles (in number) had been omitted, and many of those relating to the animal kingdom, including nearly all those on human histology, which are quite out of place in the micrographical dictionary, room would have been afforded and to spare for matters such as the above, and numerous others, of far greater interest and value to the large class of general readers, for whom such works as the Micrographic Dictionary are specially intended.

Having thus shown what we regard as the defects in the Micrographic Dictionary, the more pleasing and longer task would remain had we space to indicate its merits. As we have said, the great bulk of the articles are valuable and well selected, and it is impossible to commend in too high terms the way in which the book is "got up." It is enough, perhaps, to say that it is worthy of the publisher, printer, and artist. The illustrations are copious, clear, and well selected, and alone would confer great value upon the work, which we strongly recommend to all who may require a compendious summary of what is known on a vast variety of interesting microscopic objects, and assistance in the mode of pursuing microscopic researches.

THE MICROSCOPE AND ITS REVELATIONS. By WILLIAM B. CARPENTER, M.D., F.R.S., &c. London. Churchill.

It was only to be expected that if Dr. Carpenter undertook to write a book on the Microscope, it would be a good one, and at least not inferior to any that had hitherto been published. Such was our anticipation, and we have not been disappointed. The book is even better than we could have hoped for, for knowing as we do the great amount of literary and teaching labour performed by Dr. Carpenter, we are astonished to find that he could secure the time for producing a book in every way so complete and faithful a transcript of the subject to which it is devoted as the present volume. This work is not, in fact, as its name might seem to imply, a simple introduction to the use of the Microscope, but a treatise on this instrument, describing the principles of its construction, the various forms which are employed, their adaptations to special uses, and a survey of the various departments of science in which it has been successfully employed. The introduction consists of a sketch of the service rendered by the Microscope to science. The author indicates here the various facts observed by means of the Microscope, and points out their value as the foundation of philosophical reasoning in all those classes of phenomena to which they are related. We should have been glad to have quoted the whole of the concluding part of these observations devoted to the educational value of the Microscope. They are so applicable to the educational demands of the present day, and so in accordance with the aspirations of those who regard science and scientific research as only means to the higher end of the intellectual and moral development of man, that we can but commend them to all interested in the subject of education. We must, however, find space for the introductory remarks.

"All the advantages which have been urged at various times, with so much sense and vigour,* in favour of the study of Natural History, apply with full force to Microscopical inquiry. What better encouragement and direction can possibly be given to the exercise of the *observing* powers of a child, than to habituate him to the employment of this instrument upon the objects which immediately surround him, and then to teach him to search out novelties among those less immediately accessible? The more we limit the natural exercise of these powers, by the use of those methods of education which are generally considered to be specially advantageous for the development of the Intellect,—the more we take him from fields and woods, from hills and moors, from river-side and sea-shore, and shut him up in close school-rooms and narrow play-grounds, limiting his attention to abstractions, and cutting him off even in his hours of sport from those

* By none more forcibly than by Mr. Kingsley, in his recent little volume entitled "Glaucus, or the Wonders of the Shore."

sights and sounds of Nature which seem to be the appointed food of the youthful spirit,—the more does it seem important that he should in some way be brought into contact with her, that he should have his thoughts sometimes turned from the pages of books to those of Creation, from the teachings of Man to those of God. Now if we attempt to give this direction to the thoughts and feelings in a merely *didactic* mode, it loses that spontaneousness which is one of its most valuable features. But if we place before the young a set of objects which can scarcely fail to excite their healthful curiosity, satisfying this only so far as to leave them still inquirers, and stimulating their interest from time to time by the disclosure of such new wonders as arouse new feelings of delight, they come to look upon the pursuit as an ever-fresh fountain of happiness and enjoyment, and to seek every opportunity of following it for themselves.

"There are no circumstances or conditions of life, which need be altogether cut off from these sources of interest and improvement. Those who are brought up amidst the wholesome influences of a country life, have, it is true, the greatest direct opportunities of thus drawing from the Natural Creation the appropriate nurture for their own spiritual life. But the very familiarity of the objects around them, prevents these from exerting their most wholesome influence, unless they be led to see how much there is *beneath the surface* even of what they seem to know best; and in rightly training them to look for this, how many educational objects,—physical, intellectual, and moral,—may be answered at the same time! 'A walk without an object,' says Mr. Kingsley, 'unless in the most lovely and novel scenery, is a poor exercise; and as a recreation utterly nill. If we wish rural walks to do our children any good, we must give them a love for rural sights, an object in every walk; we must teach them—and we can teach them—to find wonder in every insect, sublimity in every hedge-row, the records of past worlds in every pebble, and boundless fertility upon the barren shore; and so, by teaching them to make full use of that limited sphere in which they now are, make them faithful in a few things, that they may be fit hereafter to be rulers over much.' What can be a more effectual means of turning such opportunities to the best account, than the employment of an aid which not only multiplies almost infinitely the sources of interest presented by the objects with which our eyes are most familiar, but finds inexhaustible life where all seems lifeless, ceaseless activity where all seems motionless, perpetual change where all seems inert?—Turn, on the other hand, to the young who are growing up in our great towns, in the heart of the vast Metropolis, whose range of vision is limited on every side by bricks and mortar, who rarely see a green leaf or a fresh blade of grass, and whose knowledge of animal life is practically limited to the dozen or two of creatures that everywhere attach themselves to the companionship of Man, and shape their habits by his. To attempt to inspire a real love of Nature by books and pictures, in those who have never felt her influences, is almost hopeless. A child may be interested by accounts of her wonders, as by any other instructive narrative; but they have little of *life* or *reality* in his mind,—far less than has the story of adventure which appeals to his own sympathies, or even than the fairy tale which charms and fixes his imagination. But here the Microscope may be introduced with all the more advantage, as being almost the only means accessible under such circumstances, for supplying what is needed. A single rural or even suburban walk will afford stores of pleasurable occupation for weeks, in the examination of its collected treasures. A large glass jar may be easily made to teem with life, in almost as many and as varied forms as could be found by the unaided eye in long and toilsome voyages over the wide ocean; and a never-ending source of amusement is afforded by the observation of their growth, their changes, their movements, their

habits. The school-boy thus trained, looks forward to the holiday which shall enable him to search afresh in some favourite pool, or to explore the wonders of some stagnant basin, with as much zest as the keenest sportsman longs for a day's shooting on the moors, or a day's fishing in the best trout-stream; and with this great advantage over him,—that his excursion is only the beginning of a fresh stock of enjoyment, instead of being in itself the whole."

In the part of the work devoted to the description of the Microscope, the most full and liberal account is given of the various kinds of instruments constructed by various makers. No one can, we think, complain that they are not fairly treated by Dr. Carpenter. Whenever an instrument exhibits a new feature or application it has been fully described, so that the possessor of this volume will have an ample guide in the purchase of the multiplicity of instruments now courting his attention. The notice of accessory apparatus is not less minute, fair, and comprehensive. Those who become acquainted with the Microscope for the first time by this work, will be, perhaps, somewhat dismayed at the extent, variety, and expense of the microscopic apparatus, but let them be comforted with the following words:—

"It cannot be too strongly or too constantly kept in view, that the value of the results of Microscopic inquiry will depend far more upon the sagacity, perseverance, and accuracy of the observer, than upon the elaborateness of his instrument. The most perfect Microscope ever made, in the hands of one who knows not how to turn it to account, is valueless; in the hands of a careless, a hasty, or a prejudiced observer, it is worse than valueless, as furnishing new contributions to the already large stock of errors that pass under the guise of scientific truths. On the other hand, the least costly Microscope that has ever been constructed, how limited soever its powers, provided that it gives no *false* appearances, shall furnish to him who knows what *may* be done with it, a means of turning to an account, profitable alike to science and to his own immortal spirit, those hours which might otherwise be passed in languid *ennui*, or in frivolous or degrading amusements,* and even of immortalizing his name by the discovery of secrets in Nature as yet undreamed of. A very large proportion of the great achievements of Microscopic research that have been noticed in the preceding outline, have been made by the instrumentality of microscopes which would be generally condemned in the present day as utterly unfit for any scientific purpose; and it cannot for a moment be supposed, that the field which Nature presents for the prosecution of inquiries with instruments of comparatively limited capacity, has been in any appreciable degree exhausted. On the contrary, what *has been* done by these and scarcely superior instruments, only shows how much there is *to be* done. The author may be excused for citing, as an apposite example of his meaning, the curious results he has recently obtained from the study of the development of the *Purpura lapillus* (rockwhelk), which will be detailed in their appropriate place (Chap. XII.); for these were obtained almost entirely

* "I have seen," says Mr. Kingsley, "the cultivated man, craving for travel and success in life, pent up in the drudgery of London work, and yet keeping his spirit calm, and his morals perhaps all the more righteous, by spending over his Microscope evenings which would too probably have generally been wasted at the theatre."

by the aid of *single lenses*, the Compound Microscope having been only occasionally applied to, for the verification of what had been previously worked out, or for the examination of such minute details as the power employed did not suffice to reveal.

"But it should be urged upon such as are anxious to do service to Science, by the publication of discoveries which they suppose themselves to have made with comparatively imperfect instruments, that they will do well to refrain from bringing these forward, until they shall have obtained the opportunity of verifying them with better. It is, as already remarked, when an object is *least* clearly seen, that there is *most* room for the exercise of the imagination; and there was sound sense in the reply once made by a veteran observer, to one who had been telling him of wonderful discoveries which another was said to have made '*in spite* of the badness of his Microscope,'—'No, Sir, it was *in consequence* of the badness of his Microscope.' If those who observe, with however humble an instrument, will but rigidly observe the rule of recording only what they can *clearly see*, they can neither go far astray themselves, nor seriously mislead others."

The description of apparatus is followed by a very complete account of the various methods adopted for mounting and preparing objects.

The second part of the work consists of an account of the various forms of animal and vegetable life, which are the subjects of microscopic research. In this department it was to be expected that Dr. Carpenter would display his great knowledge of Biological phenomena, and few persons, however profound their knowledge of particular departments of anatomical research and physiological laws, will fail to read these chapters without adding to their stores of knowledge and widening their sphere of thought.

This section of the work is almost a complete *resumé* of the present state of our knowledge of the histology, reproduction, and development of the vegetable and animal kingdom; and Dr. Carpenter, by his general remarks, has given a consistency and unity to these subjects, which will recommend his book where microscopical research is not the object of study. As a specimen of the manner in which these general subjects are treated, we give the following:—

"279. The Reproduction of the Rotifera has not yet been completely elucidated. There is no instance, in this group, in which multiplication by gemmation or spontaneous fission is certainly known to take place; but the occurrence of clusters formed by the aggregation of a number of individuals of *Conochilus*, adherent by their tails, and enclosed within a common *lorica*, would seem to indicate that these clusters, like the aggregations of Polygastrica, Bryozoa, and Tunicata, must have been formed by continuous growth from a single individual. The ordinary method of multiplication, however, is commonly supposed to be by a proper generative act; as distinct sexes have been discovered in several individuals, and the act of sexual union has been witnessed. The condition of the male of the remarkable genus described by Mr. Dalrymple (loc. cit.) is a most extraordinary one; for it possesses no mandibles, pharynx, œsophagus, stomach, nor hepatic glands; having, in fact, no other organs fully developed, than

those of generation. It would appear, therefore, quite unfit to obtain aliment for itself; and its existence is probably a very brief one, being continued only so long as the store of nutriment supplied by the egg remains unexhausted. In *Rotifer*, however, as in by far the larger proportion of the class, no males have been discovered; and it remains doubtful whether the two sexes are united in the same individual, or whether the males are produced only at certain times. The female organ consists but of a single ovarian sac, which frequently occupies a large part of the cavity of the body, and which opens at its lower end by a narrow orifice into the cloaca. Although the number of eggs in these animals is so small, yet the rapidity with which the whole process of their development and maturation is accomplished, renders the multiplication of the race very rapid. The egg of the *Hydatina* is extruded from the cloaca within a few hours after the first rudiment of it is visible; and within twelve hours more the shell bursts, and the young animal comes forth. In the *Rotifer* and several other genera, the development of the embryo takes place whilst the egg is yet retained within the body of the parent (fig. 201, *k*), and the young are extruded alive; whilst in some other instances, the eggs, after their extrusion, remain attached to the posterior extremity of the body (fig. 200), until the young are set free. In general it would seem that, whether the rupture of the egg-membrane takes place before or after the egg has left the body, the germinal mass within it is developed at once into the form of the young animal, which resembles that of its parent; no preliminary metamorphosis being gone through, nor any parts developed which are not to be permanent. The transparency of the egg-membrane, and also of the tissues of the parent Rotifer, allows the process of development to be watched, even when the egg is retained within the body; and it is curious to observe, at a very early period, not merely the red eye-spot of the embryo, but also a distinct ciliary movement. The multiplication of *Hydatina* (in which genus three or four eggs are deposited at once, and their development completed out of the body) takes place so rapidly, that, according to the estimate of Professor Ehrenberg, nearly *seventeen millions* may be produced within twenty-four days from a single individual. Even in those species which usually hatch their eggs within their bodies, a different set of ova is occasionally developed, which are furnished with a thick glutinous investment: these, which are extruded entire, and are laid one upon another, so as at last to form masses of considerable size in proportion to the bulk of the animals, seem not to be destined to come so early to maturity, but very probably remain dormant during the whole winter season, so as to produce a new brood in the spring. These 'winter-eggs' are inferred by Mr. Huxley, from the history of their development, to be really *gemmæ* produced by a non-sexual operation; while the bodies commonly called ova, he considers to be true generative products. Dr. Cohn has recently informed the author, however, that he has ascertained by direct experiment upon those species in which the sexes are distinct, that the bodies commonly termed ova (figs. 200, 201), are really *internal gemmæ*, since they are reproduced, through many successions, without any sexual process, just like the external gemmæ of *Hydra* (§ 301), or the internal gemmæ of *Entomostraca* and *Aphides* (Chap. XVI). And this view appears to himself to be more accordant with general physiological analogy, than that of Mr. Huxley, since, in the other instances referred to, as in the Rotifera, the multiplication by gemmation goes on rapidly whilst food and warmth are abundantly supplied; but gives place to the true generative process, when the nutritive activity is lowered by their withdrawal."

Although, of course, Dr. Carpenter has drawn largely on the researches of others, the work contains much matter which

may be regarded as exclusively his own. Such is his account of the Structure of Shells, from which we give an extract relating to the forms assumed by the Brachiopoda.

"341. The shells of *Terebratulæ*, and of several other genera of *Brachiopoda*, are distinguished by peculiarities of structure, which serve to distinguish them from all others. When thin sections of them are microscopically examined, they exhibit the appearance of long flattened prisms (fig. 259, *b*), which are arranged with such obliquity, that their rounded extremeties crop out upon the inner surface of the shell in an imbricated (tile-like) manner (*a*). All true *Terebratulidæ*, both recent and fossil, exhibit another very remarkable peculiarity; namely, the presence of a large number of *perforations* in the shell, generally passing nearly perpendicularly from one surface to the other (as is shown in vertical sections (fig. 261), and terminating internally by open orifices (fig. 259), whilst exter-

Fig. 259.

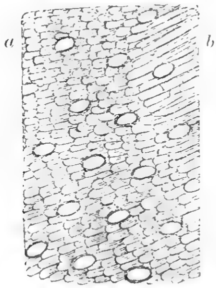


Fig. 260.

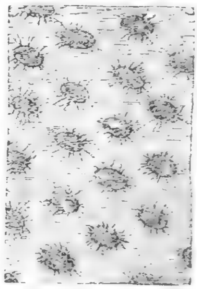
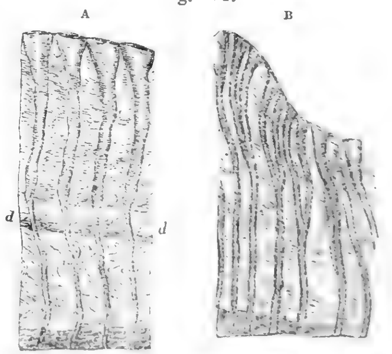


FIG. 259. Internal surface (*a*), and oblique section (*b*), of Shell of *Terebratula* (Waldheimia) *australis*.
FIG. 260. External surface of the same.

nally they are covered by the periostracum (fig. 260). Their diameter is greatest towards the external surface, where they sometimes expand suddenly, so as to become trumpet-shaped; and it is usually narrowed rather suddenly, when, as sometimes happens, a new internal layer is formed as a lining to the preceding (fig. 261, A, *d d*). Hence the diameter of these canals, as shown in different transverse sections of one and the same shell, will vary according to the part of its thickness which the section happens to traverse. The different species of *Terebratulidæ*, however, present very striking diversities in the size and closeness of the canals, as shown by sections taken in corresponding parts of their shells; three examples of this kind are given for the sake of comparison in figs. 262-264. These canal

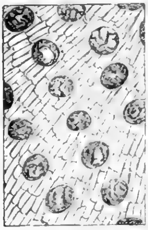
Fig. 261.

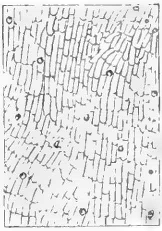


Vertical sections of Shell of *Terebratula* (Waldheimia) *australis*:—showing at A the canals opening by large trumpet-shaped orifices on the outer surface, and contracting at *d d* into narrow tubes; and presenting at B a bifurcation of the canals.

are occupied, in the living state, by tubular prolongations of the mantle, the interior of which is filled with a fluid containing minute cells and

Fig. 262. Fig. 263. Fig. 264.





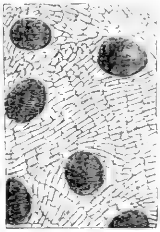


FIG. 262. Horizontal Section of Shell of *Terebratula bullata* (fossil, oolite).
FIG. 263. Ditto . . . . of *Megerlia lima* (fossil, chalk).
FIG. 264. Ditto . . . . of *Spiriferina rostrata* (triassic).

granules, which, from its corresponding in appearance with the fluid contained in the great sinuses of the mantle, may be considered to be the animal's blood. Hence these cæcal tubes may be inferred to possess a respiratory function; and seem to be analogous to tubes of a very similar nature, which extend into the 'test' of many Tunicata from their sinus-system (§ 334). In the family *Rhynchonellidæ*, which is represented by only two recent species (the *Rh. psittacea* and *Rh. nigricans*, both of which formerly ranked as Terebratulæ), but which contains a very large proportion of fossil Brachiopods, these canals are entirely absent; so that the uniformity of their presence in the Terebratulidæ, and of their absence in the Rhynchonellidæ, supplies a character of great value in the discrimination of the fossil shells belonging to these two groups respectively. Great caution is necessary, however, in applying this test; mere surface-markings cannot be relied on; and no statement on this point is worthy of reliance, which is not based on a microscopic examination of thin sections of the shell. In the families *Spiriferidæ* and *Strophonemidæ*, on the other hand, some species possess the perforations, whilst others are destitute of them; so that their presence or absence *there* only serves to mark out subordinate groups. This, however, is what holds good in regard to characters of almost every description, in other departments of Natural History, as well as in this; a character which is of fundamental importance from its close relation to the general plan of organisation in one group, being, from its want of constancy, of far less account in another."*

The illustrations in the above extract will give an idea of the woodcuts with which the work abounds. These are all executed by Mr. Bagg; and the whole work is got up with the same care that characterizes Mr. Churchill's series of manuals.

* For a particular account of the Author's researches on this group, see his memoir on the subject, forming part of the Introduction of Mr. Davidson's 'Monograph of the British Fossil Brachiopoda,' published by the Palæontographical Society.

NOTES AND CORRESPONDENCE.

The Proboscis of the Blow-fly.—Ever since I have had a good microscope, this has been a favourite and interesting object to me, and partly in consequence of a photograph of it having appeared in the third Number of this Journal, I was induced to send the following query to the editors, which appeared in the fifth Number, hoping that by thus calling attention to the subject some one of competent knowledge and skill would take it up. "Query. In what work may there be found a description of the exceedingly beautiful structure of the proboscis of the Fly, more especially of what are termed, in the explanation of the Plate, in the third Number of this Journal 'divided absorbent tubes?'" This query, unfortunately, has not been noticed; and consequently, in this short communication, I wish to direct the attention of your readers to some points of the beautiful and curious *structure* of this organ, and trust that some one learned in these matters will endeavour to explain the *functions* of the parts described. I have an additional inducement to do this since there appears to be in published works diverse views as to the functions of these beautiful spirals. Whilst in the description of Plate VII. of the Transactions of the Microscopical Society, contained in the third Number of this Journal, they are termed "divided absorbent tubes," in the 'Micrographic Dictionary,' just completed, the proboscis is mentioned (article Musca, p. 444) as being "kept expanded by a beautiful and elastic frame-work of modified tracheæ."

Adopting provisionally the term "divided absorbent tubes," each tube appears to be made up, as it were, of divided turns of a spiral fibre, which, to avoid circumlocution, I shall call *divided spirals;* and in fig. 1, I have

Fig. 1.

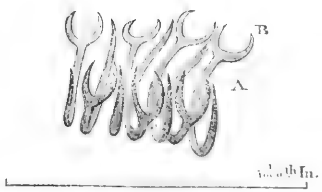
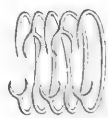


Fig. 2.



made a very careful drawing, by the camera lucida, of a portion of one of these tubes, magnified about 800 diameters. But the opposed ends of these divided spirals do not terminate similarly; for while one extremity exhibits a fine point, the other is forked, dividing into two portions, each having a

fine point, and which, together, are very nearly the shape of a semicircle.

These simple points (A, fig. 1) and forks (B) alternate along both sides of the line of division, the forked extremity of one divided spiral being placed in juxtaposition with the simple point of the adjacent fibre. It is evident that the portion which I have endeavoured to draw, although showing this structure very clearly, is rather distorted in the process of mounting (mounted by Topping); but from what may be seen in other portions of this specimen, I believe that a tube quite undistorted would present something of the appearance of figure 2. This very beautiful structure is obscurely indicated in the positive photograph by Mr. Delves, alluded to above. By carefully examining the proboscis with a power of about 200 diameters, it appears as though these tubes are connected together by a delicate, structureless membrane, *not on the same plane*, with the membrane accurately represented in figure 29 *a*, Plate 26, of the 'Micrographic Dictionary;' in which figure, however, the peculiar features of the "divided absorbent tube" do not appear (with all due deference to the talented Authors) to be characteristically drawn.—G. HUNT, *Handsworth, near Birmingham.*

Aperture of Object-Glasses.—Professor Bailey having admitted that the effect of balsam mounting is to cause a reduction of the angle of aperture of the object-glass, any further remarks from me in defence of this position are almost superfluous.

A scientific controversy should not, perhaps, be avoided, if its sole end is to establish the truth—my arguments on the subject in question have been entirely dictated by this motive. If I have at all misunderstood Professor Bailey, it has not been either intentionally or wilfully, for the few words to which his last comments relate might readily bear the interpretation that I put upon them. He stated that my arguments were erroneous, and gave as the single reason that I had "traced the rays into the balsam instead of out of it;" I must confess that I inferred from this that Professor Bailey meant to imply that a ray traced outwards would be refracted at a different angle of emergence relative to the degree of incidence, than if the same ray was traced inwards. As this can never be the case, and the discussion related to one point only, viz., the aperture of the object-glass, *or angle of rays collected from an object in balsam*, therefore, with all submission, I think that I was not in fault in saying that it comes to precisely the same thing if the rays are traced into the refractive medium or out of it, as far as the actual result is concerned.

The refractive effect of balsam causes but a small comparative difference in favour of extreme degrees: for example, referring to my former experiments, two object-glasses, one of 146° and the other of 105° of aperture, will be reduced over an object in balsam to 75° and 68°, being a difference of *forty-one degrees* in air, but only *seven degrees* in balsam. In discussing this subject, I have omitted to mention that balsam-mounting not only has the effect of another optical combination by the refractive medium reducing the aperture, but that the same refraction also slightly diminishes the magnifying power of the object-glass. This may be easily proved by measuring the length of an object both before and after fluid balsam has been allowed to run under the thin glass cover, using a 1-12th objective.—F. H. WENHAM.

Application of Collodion to the Production of Stage and Eye-piece Micrometers for the Microscope.—A cheap stage-micrometer may be made by taking a cast in collodion from a piece of ruled glass, and mounting the cast thus taken as a microscopic slide. The specimen sent with this is one of many casts taken in this way from a piece of glass on which lines had been ruled at the distance of 1-400ths of an inch. Every irregularity in the original is accurately copied on the collodion; and by this planone correctly-ruled micrometer on glass may be made to furnish any require dnumber of exact copies.

An eye-piece micrometer may be made in a very simple manner, by employing the photographic camera to reduce a coarsely-graduated original to any degree of minuteness which may be desired. The specimens sent with this are copies of a scale of inches and tenths, reduced in this way either to tenths and hundredths or to twentieths and two-hundredths; and also of a diagonal scale reduced so as to furnish for the eye-piece of the microscope a micrometer of which the divisions are hundredths and thousandths of an inch. The originals are of glass, covered with black paper or black varnish, on which lines were drawn with a knife-point. These micrometers are not perhaps so sharp as those ruled by machines, but they may be made at a much smaller cost, of any required pattern and size, and by those who have no machines within their reach.—W. HODGSON, *Old Brathay.*

Note on Pinnularia.—At the first page of this volume of the 'Quarterly Journal of Microscopical Science,' Dr. Gregory, noticing a *Pinnularia*, for which he had adopted Professor Smith's name of *Pinnularia latestriata*, proceeds thus:—"I could find no figure of this species in any work to which I had access, neither in Ehrenberg's Atlas in 1838, in Kutzing,

nor in Rabenhorst. Nor did any English observer know it. But I now find that Ehrenberg had described it as *P. borealis*, ten or twelve years ago, although his figure, which, if published, appeared in the Berlin Transactions or the Berlin Monthly Reports, was entirely unknown to all our authorities in this country, none of whom, more than myself, have been able to consult Ehrenberg's very numerous papers on the Berlin Transactions or Monthly Reports, except as quoted by Kutzing or Rabenhorst, neither of whom noticed this species. I mention these facts to explain how it was that a species long ago described, and I believe figured, by Ehrenberg, was regarded by all our authorities as new when I found it in the Mull earth two years ago."

Allow me briefly and respectfully to state, that the *Pinnularia borealis* is figured by Kutzing, and is figured by Rabenhorst; and that Kutzing copied his figure from Ehrenberg's American Tabulæ, a work by no means unknown in this country.—J.

On Micrometers and Micrometry.—In the last number of the 'Microscopical Journal,' there is a paper by Dr. Robertson, quoted from the 'Monthly Journal of Medical Science,' recommending an ingenious form of eye-piece micrometer, proposed by Herman Welcher, a medical student at Giessen, on which I wish to offer a few observations.

Micrometry, as affected by the compound microscope, consists in the comparison of the magnified image of the object with the similarly-magnified image of a body whose dimensions are known, the most convenient for the purpose being a piece of glass ruled with fine divisions, called a *stage micrometer*. This comparison cannot, as Dr. Robertson correctly observes, be made *directly* by laying the object on the divided scale; but it may be made *indirectly*, either by the camera lucida, as practised by Mr. Lister, or by means of an eye-piece micrometer. The latter method, in addition to convenience in application, has the further advantage of subdividing the divisions on the stage to an extent corresponding to the magnifying power employed; but it also has the disadvantage of enlarging their errors in the same proportion.

In ruling a micrometer, the elasticity of the materials of the dividing engine, the friction of its moving parts, or the freedom of motion necessarily allowed in order to diminish that friction, will produce a very slight inequality in the individual divisions; but if these be carefully examined, their errors will generally be found to be alternately *plus* and *minus*, in no case cumulative. It therefore follows that the sum of the errors of a number of divisions will scarcely ever exceed that

of an individual one, and will probably be much less. The advantage, then, of taking a large space of the stage micrometer as a basis for estimating the value of that in the eye-piece is quite evident; for, not only is the absolute amount of error likely to be less, but that amount will be proportionally diminished in measuring all smaller objects, whereas it would be increased in measuring larger ones.

In the micrometer recommended by Dr. Robertson, the object is made to occupy the chord of an arc, and the extent that can be measured by it is the diameter of the dotted circle described by the revolution of the point of intersection of the lines *a b* and *c d*, fig. 2, p. 155.

To find the value of this quantity, make the line *c d* parallel and coincident with one of the divisions of the stage micrometer, then turn the eye-piece half round, and when the same line is again parallel to a division, read off the number of divisions passed over, which will be equal to the chord of 180°, or twice the size of 90°. The chord, then, of any observed angle will bear the same proportion to the chord of 180°, that the sine of half the angle does to the sine of 90°; and as the latter quantity is taken as unity in the tables of sines, the calculation becomes quite easy, either by logarithms, whole numbers, or the sliding-scale. Whether this instrument is capable of the accuracy assigned to it by Dr. Robertson, must depend on the relative position of the eye-piece and the object on the stage remaining *invariable* during the operation; and this can only be insured by sound workmanship in the maker, and delicate manipulation in the observer.

The latter, however, will, I think, find some difficulty in placing the line to be measured (which may be either in the length or breadth of an object) in the exact direction of the chord of the *imaginary* circle (for there is no trace of it in the microscope); and the calculations, though simple, will become wearisome when often repeated. When Dr. Pereira was engaged on the last edition of his 'Materia Medica,' I made the measurements of the different starch-globules for him; and as I generally measured eight or ten in each specimen, I am sure that it would have taken me a much longer time than I spent over it to accomplish the task with the above instrument. The eye-piece micrometer that I used was a glass one, furnished with the fine-movement screw, described in the transactions of the Microscopical Society, and in Mr Quekett's treatise. It was divided into 250ths of an inch, and, by means of a draw-tube, was made to read 10,000ths with the quarter inch object-glass employed. The measurements may therefore be relied on to the 30,000th of an inch; for the third, or even fourth of a division can be easily estimated.

Dr. Robertson complains that in glass micrometers "the breadth of the lines is so considerable, and the shadows caused by their channels are so perplexing," that extreme accuracy is unattainable with them.

From his constantly speaking of millimeters, I conclude that the micrometers he has used are of French manufacture, some of which, as I have seen, are justly liable to his censure, for they appear to have been ruled by a diamond which cuts, or rather *splits*, the glass like that employed by glaziers. But micrometers may be obtained from most of the makers in London, in which the lines are only thick enough to be distinctly visible; and the *channels* being filled with plumbago, and having a cover cemented over them with Canada balsam, cast no shadows when in the focus of the eye-glass, the shadows which Dr. Robertson complains of, being most probably the refraction of the prismatic edges of the *channels*.—George Jackson, 30, *Church Street*, *Spitalfields*.

Mr. Amyot's Finder.—You were good enough to insert a short paper of mine on the "Finder or Indicator" in the last number of the 'Microscopical Journal;' I have since had some lithographed scales struck off for pasting on the face of the wooden instrument, and have had the pleasure of supplying a considerable number of these to gentlemen unknown to me, and to whom I have not had time to write full directions for attaching them. Indeed it is only within the last few days that I have hit upon a mode of effecting this with ease and satisfaction to myself. If you would be good enough to insert the few necessary directions which I have condensed to the utmost, you would confer an additional obligation.

Directions for attaching the Lithographic Paper Scales to the Wooden Indicator, described at page 151 *of the last Number of the Journal.*

1. Continue the lines of the four scales across the centre of the paper, using a fine-pointed pencil.
2. Perforate the central intersection of lines with a needle.
3. Cover the face of the wooden instrument with a thin layer of smooth paste, the bone disk being removed.
4. Force the little brass pin out of the bone, and replace the disk on its rabbet.
5. Place the paper on the wood, inclosing the bone, and then holding the instrument up to the light, bring the needle-hole exactly opposite to that in the bone, and ascertain with a lens that this is correctly done.
6. Smooth the paper on the wood, and before putting aside to dry again ascertain that the centres are correct.
7. In about two hours remove the middle of the paper at the ring with a sharp-pointed penknife. Take out the bone disk, replace the pin, and trim the edge of the paper so neatly that the centre-piece may fall easily in its place.

Thomas E. Amyot, *Diss*, *Norfolk*.

PROCEEDINGS OF SOCIETIES.

Microscopical Society, *December* 26, 1855.

Dr. Carpenter, President, in the chair.

H. Griesbach, Esq.; —. Pillischer, Esq.; F. Haes, Esq.; and Dr. Stevens, were balloted for, and duly elected.

A list of persons proposed as Officers and Council for the year ensuing was read, and ordered to be suspended in the Meeting-room.

Dr. Lankester read three papers, printed in the Journal.

Dr. Beale exhibited and described a new form of Microscope.

January 30, 1856.

Dr. Carpenter, President, in the chair.

J. Slade, Esq.; Dr. W. Rawlins; J. S. Gaskoines, Esq.; C. W. Quin, Esq.; C. A. Long, Esq.; and H. Sidden, Esq., were balloted for, and duly elected.

Certain proposed additions and alterations in the Laws of the Society were read, and ordered to be suspended in the Meeting-room.

Feb. 27, 1856.

Anniversary Meeting.

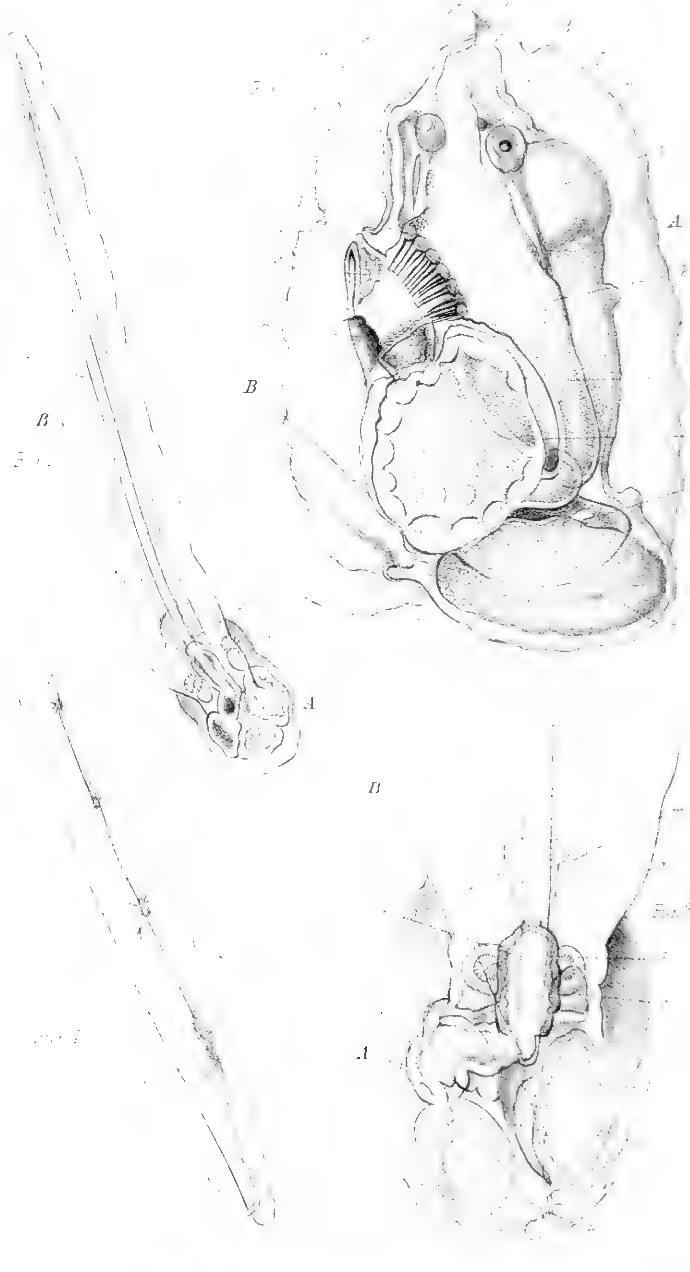
Dr. Carpenter, President, in the chair.

A report from the Council and from the Auditors of the Treasurer's accounts was read, and ordered to be received and approved.

The alterations and additions in the Laws, proposed at the last Meeting, were read and adopted.

The President then delivered an address.

Dr. Lister; H. Morris, Esq.; Chas. Rivaz, Esq.; and C. W. Gregory, Esq., were balloted for, and duly elected (see Transactions, p. 15).



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EXPLANATION OF PLATE X.

Illustrating Mr. Huxley's paper on Appendicularia.

Fig.

1.—*Appendicularia flagellum* seen from the side to which the caudal appendage is attached, *i. e.* the dorsal or hæmal side.

2.—Body of *Appendicularia*, magnified; side view.

3.—Body of *Appendicularia*, magnified; dorsal view.

4.—Caudal appendage; showing the great nerve, with its ganglionic enlargements.

A, Body. B, appendage.

a, oral aperture.

b, pharynx, giving off its lateral canals.

c, external opening of these canals.

d, ciliated circular bands, corresponding with the stigmata of the branchial sac in ordinary Ascidians; but here forming part of the wall of the canal *b*, *c*.

e, anus.

f, rectum.

g, œsophageal narrowing of pharynx.

h, right lobe of stomach.

i, left lobe.

k, testis.

l, axis of caudal appendage.

m, rounded granular masses projecting from the hæmal wall of the pharynx, and of doubtful nature.

n, Endostyle; here, as elsewhere in the Ascidians, the optical expression of the thickened bottom of a groove or fold, continuous at its edges with the epipharyngeal bands.

o, one end of the heart.

p, ganglion.

q, ciliated sac.

r, otolithic sac.

s, nerve trunk.

t, ganglionic enlargements upon its caudal portion.


Fig 2
Fig 3
Fig 4
Fig 5
Fig 7
Fig 8
Fig 9
Fig 10
Fig 11
Fig 12
Fig 13
Fig 14
Fig 17
Fig 25
Fig 27

DESCRIPTION OF PLATE XI.

Illustrating Mr. Currey's paper on the Reproductive Organs of Fungi.

Fig.

1.—A stellate spore of *Stilbospora militaris*, magnified 500 diameters.

2.—An abnormal spore of the same, magnified 350 diameters. Two of the horns have failed to grow.

3.—The apex of a filament and fascicle of spores of *Stilbospora militaris*, magnified 500 diameters.

4.—The apex of another filament and fascicle, magnified 350 diameters.

5.—A vertical section of a pulvinulus of *Stilbospora militaris*, magnified 60 diameters.

6.—Conidia of *Stilbospora militaris*, magnified 500 diameters.

7.—A fascicle of *Stilbospora militaris*, throwing out a germ-filament. Magnified 350 diameters.

8 and 9.—Asci and sporidia of the *Sphæria* accompanying *Steganosporium cellulosum*. It is probably *Sphæria amblyospora*. Magnified 220 diameters.

The ascus, fig. 9, is in an earlier stage than fig. 8, the sporidia being of a paler colour, and the gelatinous envelope not developed.

10 to 15.—Varieties of sporidia of *Steganosporium cellulosum*, magnified 220 diameters.

16 and 17.—Empty asci borne upon the stratum proliferum of *Steganosporium cellulosum*. The internal second membrane is very visible. Magnified 220 diameters.

18 and 19.—Bodies also borne upon the stratum proliferum of the *Steganosporium*. The endochrome is divided into eight portions, being apparently imperfect sporidia. Magnified 220 diameters.

20 and 21.—Ripe sporidia of *Sphæria amblyospora*, magnified 220 diameters.

22, 23, and 24.—Spores of *Steganosporium cellulosum* at the commencement of germination. Attached to one of the germ-filaments is a globular vesicle, possibly adventitious. Magnified 220 diameters.

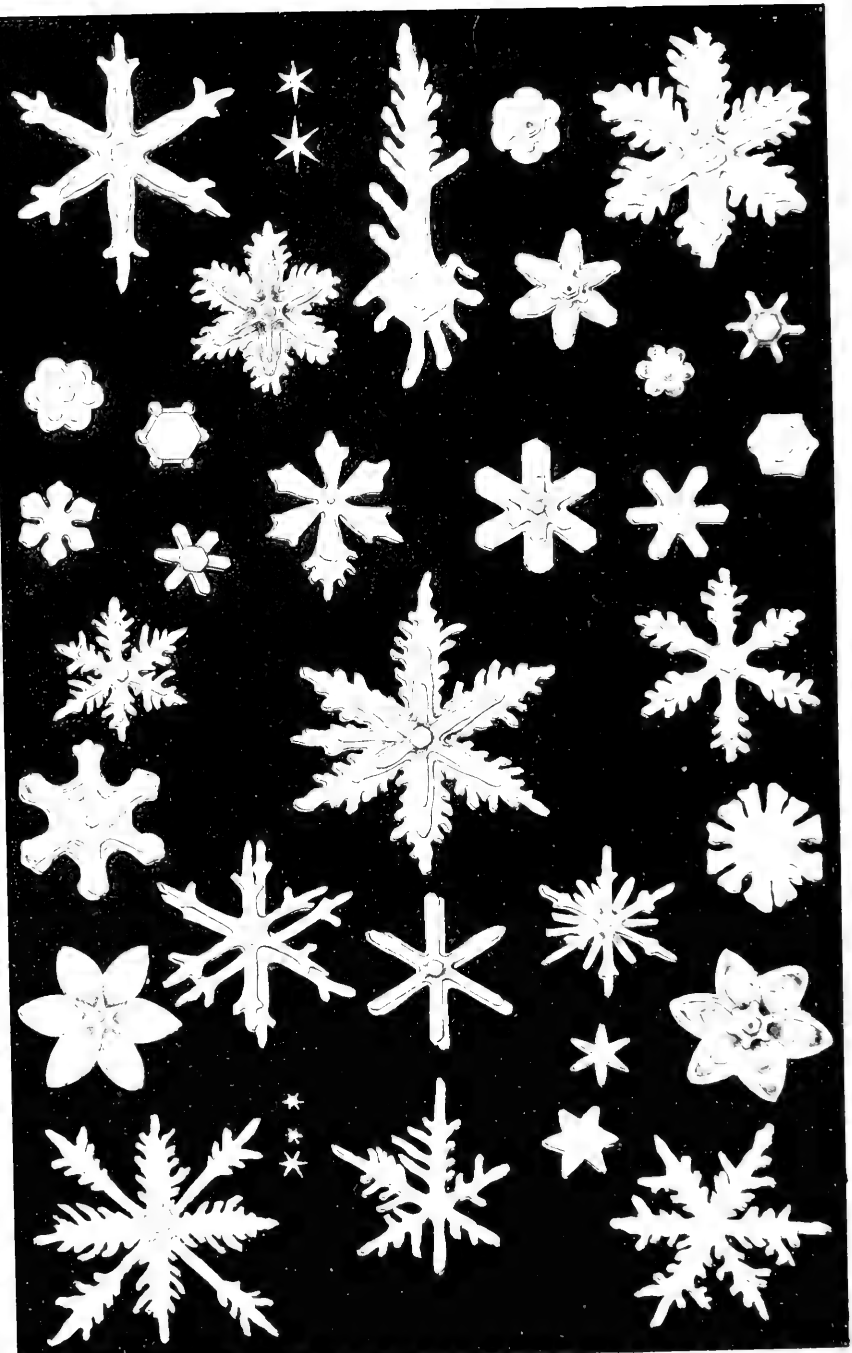
25.—A sporidium of *Steganosporium cellulosum* after about three days' germination. Magnified 220 diameters.

26.—An ascus and sporidia of *Sphæria cryptosporii*, magnified 220 diameters.

27 and 28.—Stylospores or perhaps imperfect asci of the same *Sphæria*, magnified 220 diameters.

29, 30, and 31.—Abnormal asci of *Sphæria cryptosporii*. The contents are granular, but there is no symptom of the formation of sporidia. Magnified 220 diameters.

32 and 33.—Curious instances of dehiscence of the asci of *Sphæria herbarum*. In fig. 32 the second membrane is clearly visible at both ends of the broken ascus. In fig. 33 the second membrane is reduced to a string, and encloses a single sporidium. Magnified 220 diameters.



JOURNAL OF MICROSCOPICAL SCIENCE.

DESCRIPTION OF PLATE XII.

Figures of Camphor-crystal, illustrative of the observations of Messrs. Spencer and Glaisher.

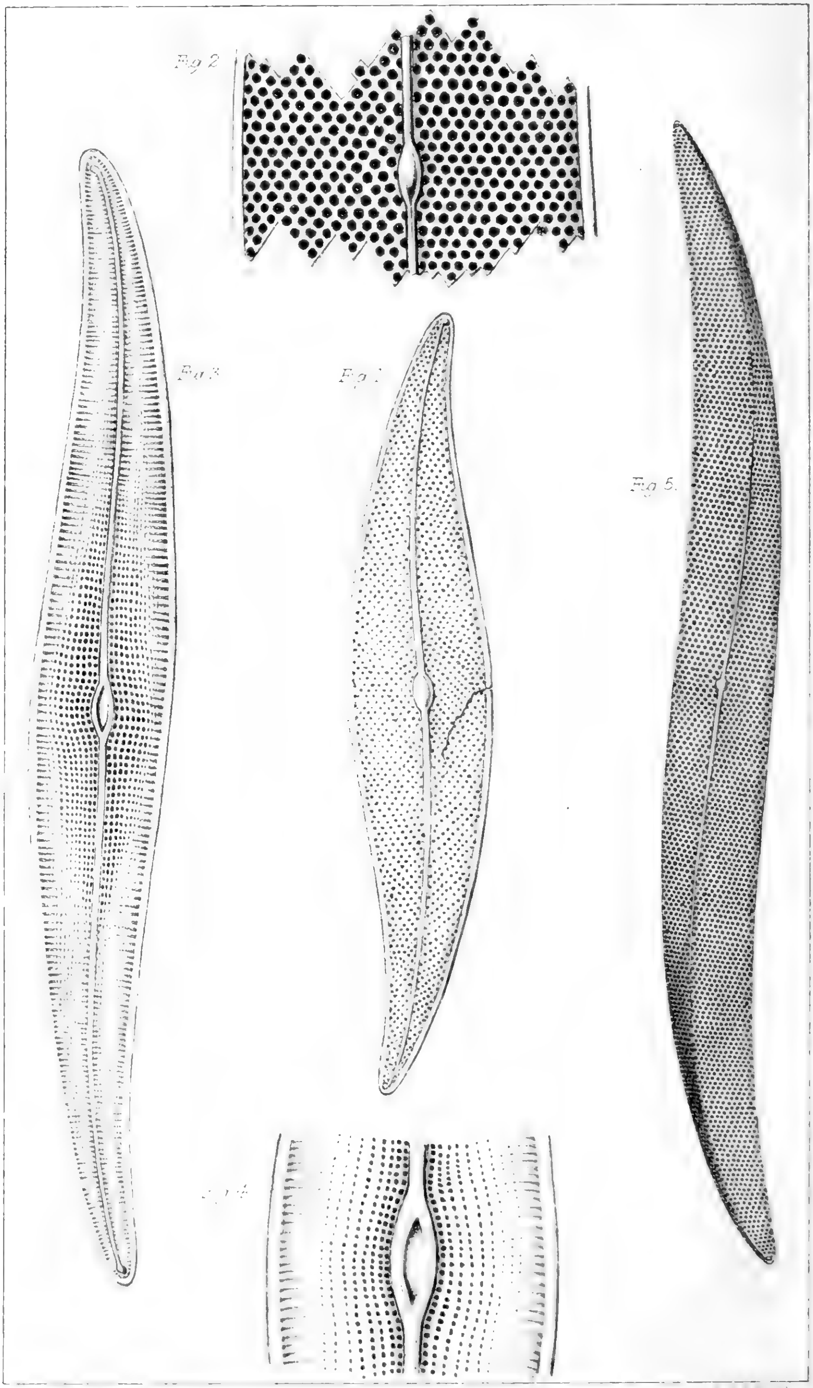


Fig 2
Fig 3
Fig 1
Fig 5.

DESCRIPTION OF PLATE XIII.,

Illustrating Dr. John Charles Hall's paper on an Easy Method of viewing certain of the Diatomaceæ.

Fig.

1.—*Pleurosigma angulatum;* colour pale chesnut: striæ 52 in ·001″; length ·0066″ to ·0100″; this figure is intended to give a *general* view of the appearance it presents when viewed with this peculiar illumination, and magnified about 800 diameters.

2.*—The same magnified about 2,000 diameters.

3.—*Pleurosigma Hippocampus;* colour pale brown: long striæ 32 in ·001″; transverse striæ 40 in ·001″; length ·0050 to ·0066″; magnified 800 diameters.

4.—The same magnified 1,200 diameters, showing both the transverse and longitudinal striæ: a portion is also seen in dots.

5.—*Pleurosigma Formosum;* colour light chesnut-brown; striæ 36 in ·001″; length ·0141 to ·0178″.

* Since the present paper was in type, I have seen the very interesting book of Dr. Carpenter "On the Microscope:" in it, at page 307, will be found an engraving, from a photograph of Mr. Wenham, of the *Pleurosigma angulatum,* as seen under a power of 15,000 diameters. On comparing this with fig. 2, in the present plate, the correctness of Mr. Fleming's delineation will at once be apparent. Dr. Carpenter, after having examined the valve with an objective having an angular aperture of 130°, and very oblique rays, states that *its hexagonal areolation* becomes very distinct;" he states also, "that when the object is accurately in focus, the hexagonal areæ are seen to be *light*, and the intervening spaces *dark*," the reverse being the case when out of focus; this, of course, does not in any way affect the question, as to the nature of these markings. I consider fig. 2, in the present plate, to be in focus.—J. C. H.

ORIGINAL COMMUNICATIONS.

NOTES *on the* STRUCTURE *of* OSCILLATORIÆ, *with a Description of a* NEW SPECIES, *possessing a most remarkable* LOCOMOTIVE POWER, *not* CILIA. By DR. F. D'ALQUEN. (Plate XIV.)

THE study of the structure of the *Oscillatoriæ* is particularly interesting, from the fact that we may not unreasonably expect to find in it a key to the singular motion from which they have received their generic name, and which now, for more than a century,* has formed an object of curiosity and interest to the microscopist without having received as yet a satisfactory explanation. In one species at least, I think, I have been able to make out the leading features of its structure and the mechanism of its locomotion. The description of this, to me, new species I wish to preface by a few observations, containing some new facts regarding the structure of *Oscillatoria* in general, which may, perhaps, interest some of your readers; in doing so, it will, however, not be necessary to refer to the general character of these interesting organisms, as they must be familiarly known to every one who is in the habit of using the microscope, and therefore I plunge at once *in medias res.*

The following different tissues are observable in the true *Oscillatoriæ*:—

1. An outer enclosing sheath;
2. A special cell-membrane, with its contents; and
3. The axis, or pith, of the filament;

which we shall consider in the order here stated.

The filaments of certain species are enclosed in sheaths (vaginæ) or continuous tubes, *never* showing any cross-markings corresponding to the striæ of the filament; they are composed of a *kind* of cellulose, since, though they remain unaffected by iodine, I have never been able to produce, on subjecting them to the usual tests for cellulose, that peculiar and striking blue colour characteristic of this substance. In other species, these tubes are wanting, or have not yet been observed. They are easily recognized; when present, they will be found projecting on one or both sides of the filament, being considerably longer than the latter. Filaments enclosed in their sheaths never, or but slightly, exhibit their peculiar motions, though they may be seen sliding in them, back

* Their movements were first observed by Adanson in 1753.

and forwards, or leaving them altogether; in the latter instance, the filament, on sliding out, receives an impetus, as it seems, from the sudden cessation of the impediment presented by the sheath to its forward motion. While sliding within its sheath, I have repeatedly observed that the tapering and bent extremity of the filament in its progress altered its position with regard to the sides of the sheath, now pointing upwards, now downwards; performing, therefore, a kind of rotation around its own axis in its progress.

The filaments themselves have been supposed to consist wholly of protoplasm; this view is not correct, since the protoplasm is enclosed in a proper cell-membrane, which has not, to my knowledge, been noticed before. This cellulose coat *always* shows the cross-markings corresponding to the striæ when such were observable in the filament, and which divide it into distinct joints or cells; these cells, however, seem to be what Kützing calls "cellulæ hologonimicæ" cells, completely filled out by the gonimic substance, or endochrome, which circumstance causes the cells to resume their former shape, after desiccation, on the addition of water, and accounts for the difficulty of demonstrating their structure. They form, with the protoplasm deposited in them, annular bands or concentric rings, around the solid axis of the filament (formatio perigenata). A reference to Pl. XIV., fig 7, will render its structure more intelligible. The presence of this cell-membrane may be best demonstrated by breaking up the filaments, either by moving the thin glass cover, or by cutting through a mass of them in all directions with a pair of fine dissecting knives. On now examining the slide, in most instances many detached empty pieces of this cell-membrane, with its striæ, will be found, as well as filaments partly deprived of the protoplasm, showing in *those* places the empty, striated cellulose coat, figs. 1, 2. On the subsequent addition of iodine all these appearances will become unmistakeably evident; the entire portions of the filament turning brown or red, while the empty, with its striæ, remain either unaffected, or at most present a slight yellowish tint, as is frequently the case with cellulose when old, for instance. (Pl. XIV., figs. 3, 8, 11.) Many specimens, however, do not readily show the above appearances, but require some trouble and management, while others do so readily enough; this arises from the peculiar state they are in; as a general rule, I found that those which admit of being easily broken up are the most fit for demonstrating this cell-membrane. In case it might be imagined I had mistaken the external enclosing sheath for the cell-membrane, I will observe that I have repeatedly isolated

filaments plainly enclosed in their sheaths, and have invariably been able to demonstrate the different tissues referred to, viz., the plain *unstriated* cellulose sheath, and the *striated* special or proper cell-membrane of the filament, deprived of its protoplasm. Moreover, the sheaths *never* have any striæ corresponding to the joints of the filament, and I am rather inclined to think that other observers, mistaking the cell-membrane for the enclosing sheath, have been prevented from earlier establishing the presence of the former, because I am convinced, as it has been stated that the sheaths *seldom* show any striæ, that, where these striæ *were* observed, the cell-membrane has been mistaken for the sheath.

With regard to the contents of this cell-membrane, it has already been stated that the protoplasm (or endochrome, since it is coloured in the *Oscillatoriæ*) is deposited within it, in the form of circular bands or rings, around the axis of the cylindrical filament; they are evidently of a nitrogenous composition, coloured by chlorophyll; iodine turns them brown or red, and syrup and dilute sulphuric acid produce a beautiful rose colour. The cells seem, however, not uniformly filled with it, but its deposition is in some places less dense than in others, as, for instance, in the centre. This circumstance, as well as that the cells are formed round the solid axis of the filament, must be borne in mind on examining the filaments while under the action of various chemical reagents. By means of these latter, I think, it may be satisfactorily proved that the filaments are really composed of separate cells; syrup causes them to contract by *ex*osmose, and, if it is replaced by water, they resume their original shape by *en*dosmose (figs. 4, 5, 6). Another question, however, is, are these cells in simple apposition without an intervening *cellulose* wall, or what kind of connexion, if any, exists between them? This question is not easily answered, but I am almost convinced that the striæ of the cell-membrane represent distinct joints, forming a cellulose wall, as represented in the ideal section, fig. 7 *b*, because I have never observed the endochrome recede beyond the striæ on the addition of a strong solution of chloride of calcium; and the lenticular disks (fig. 9), or single joints, when on end, can bear any pressure short of their entire destruction without displacement of the endochrome, which would hardly be the case if it were not enclosed within a proper cell. Further, in detached empty pieces of the cell-membrane, some of the striæ are often seen out of their natural position, dividing the cells obliquely, having been ruptured; and lastly, as there can be hardly any doubt that the filaments consist of a series of

cells, I think, from the presence of the proper cell-membrane, it might be reasonably inferred that the septa likewise consisted of cellulose, though difficult of positive demonstration on account of their minute and delicate structure. On the other hand, I must not omit to mention that I witnessed what would lead one to think that a kind of immediate contact existed between the cell contents; so soon as the points *a* and *b* in fig. 8, which represents a part of a filament under the action of iodine, began to recede from the cross-markings, the opposite portions in the intermediate adjoining cells retracted simultaneously, just as if a *separation* had taken place.

The axis of the filament may be compared to the pith or medullary sheath (stratum medullare) of the Dicotyledons; it is solid, highly refractive, but slightly affected by iodine, and, under a very high power, a granular appearance may be distinctly seen in the very centre when the filaments are broken up, and a single joint, which on end resembles a lenticular disc, is examined. If the filaments are allowed to dry spontaneously on a glass slide, a greenish thread may, with a little care, be traced running through the middle of the filament from one end to another. This is more decidedly the case if the filaments have been previously treated by iodine, fig. 10. While moist, no trace of this thread is to be seen, owing to its being almost colourless, and rendered transparent by the water; after desiccation, however, it acquires colour by condensation or shrinking, and becomes visible; sometimes, also, it will be found protruding, and in other instances I have seen it keeping up the connexion of cells, otherwise separated, fig. 11. After the addition of a weak syrup, I have also frequently observed an appearance which seems to countenance the view I have taken, and is shown in fig. 4.

With regard to their propagation nothing positive is known. If kept for some time they gradually lose their green colour; those exposed to the sun much sooner, I think, than others less exposed to its direct rays; the stratum eventually becoming brown, sinks to the bottom of the containing vessel; it presents a granular layer, embodying great numbers of filaments in all stages of decay, and, what is very singular, a great number of *Amœbæ* will be found feasting on them, with swarms of lively Infusoria of the *Monadina* kind, briskly flourishing their single flagelliform cilium about in all directions. I must also mention here a modification the filaments are sometimes observed to undergo, which is represented in figs. 12 and 13. Some of the cells, namely, contract in the middle, and their colour becomes much deeper and more

brilliant; in other instances the cells assume more of a globular shape, and in this case, the filament, which is usually straight, deviates to the right or left after each globular expansion, and from both sides tapers down into it. I believe the latter form is but a more mature state of the former; and ultimately, at these joints, the filaments separate, setting the globular cells free, which may, perhaps, justly be regarded as *gonidia.* In other filaments the striæ are formed; as it seems, by a number of granules, though I believe they are in reality to be found on each side of the cross-markings. As these granules are only observable in some of the filaments, and in others of the same species not, I think they denote a peculiar stage of development, and I am strongly impressed with the notion that these bodies are in some way connected with reproduction.

The growth of the *Oscillatoriæ* has been stated by some to be so rapid that they grow 10-12 times their length in as many hours, and others have gone so far as to attribute their motions to the rapidity of their growth. My observations have taught me to regard these notions as entirely unfounded and fanciful. Even Kützing seems to share these extravagant notions regarding their growth. He says ('Phycologia Germ. p. 157, note): "All the *Oscillatoriæ* grow so fast that their growth may be watched and followed up while under observation with the microscope; this fact explains the phenomenon, that when they are slowly dried on paper in masses, the filaments are *prolonged* in all directions, forming a ray around the mass." With all due regard for this distinguished algologist, I think the fact cited admits of another, and what seems to me the true explanation; the filaments, namely, creep out from the mass, if I may apply this term to their motions, wherever the presence of water facilitates their movements; in drying a mass of them on paper, the water will naturally collect for some time at its circumference, and allow the filaments to riggle out, forming thus the ray mentioned by Kützing. The formation of this ray is, therefore, due to their *protrusion*, and not to a *prolongation* of the filaments themselves, which alone is implied when speaking of their growth. I have frequently observed, if a small portion of the flaky stratum of *Oscillatoria*, of a deep, glossy greenish-black colour, as found under damp walls, covering the damp ground to the extent of several feet, be placed in a watch-glass with water, in a short time nearly the whole extent of the glass will be found covered with single filaments, forming a kind of pellicle, and at first sight this might be taken for an instance of their remarkable growth; but on examination, the

small portion of stratum will be found almost completely deserted, bare, deprived of its deep glossy colour, which depended upon the presence of crowded masses of filaments, which have forsaken their home and wandered forth under the stimulus of the surrounding liquid element. Strange to say, after about a fortnight the sides of the glass were less crowded, the stratum having regained a little more colour, and one could almost feel inclined to attach some truth to the *naïve* statement of the same observer, that the filaments leave their sheaths to which they return when it is cold, &c. As everything relating to their natural history is of some interest, I will mention another observation I accidentally made. Having emptied a bottle containing a stock of *Oscillatoria*, and finding the sides of the bottle in several places covered with them, I detached them from the sides, having previously filled the bottle with water; the next morning I observed, with some surprise, the rising bottom of the bottle covered with a tolerably dense green stratum, but not a trace of any of the detached pieces which I had left could be found; they must, therefore, have crowded together, forming a little colony of their own, being, as it seems, of a social disposition, and gregarious in their habits.

The new species of *Oscillatoria* * which I shall now describe is peculiarly interesting, from its being apparently in a state of transition, not having its cells filled out by chlorophyll, and thus admitting of a better observation of its internal structure; it was found forming an extensive, partly frothy, stratum, of a dirty-green colour (drying blue-green or æruginous), on stagnant water, and on being disturbed it separated into small threads, having a twisted, curly appearance. The average diameter of filaments is 1-6000″; diameter of cells about the same; they are highly refractive, and the most active I have as yet observed. I have stated they were apparently in a transition state, because, besides those which have their cells not coloured by chlorophyll, and which form the great mass of them, there are others with only a few cells filled out, appearing green; and again, others with all the cells of the filaments filled up, and in this, what I suppose to be their mature state, they resemble the usual forms the *Oscillatoriæ* present, viz., filaments of a green colour, only that in this instance the striæ are very indistinctly developed. In those with transparent, uncoloured cells the striæ are well

* Though apparently common, I have not been able to identify it with any of the great number described by Kützing; but as it may nevertheless be known, I have refrained for the present from introducing it under a specific name.

marked; and through the middle of the filament runs a deep green thread, somewhat tortuous like a swollen vein, perforating and connecting the cells from one end of the filament to the other, forming its axis, and presenting an instance of a contractile substance serving as an apparatus for locomotion unexampled in the annals of vegetable physiology (figs. 14, 15). Their structure is, however, not so simple as one would imagine from the description and drawings I have given; they present, on the contrary, so complicated and varying an aspect, that it is next to impossible to give an adequate representation of them. However, under a good object-glass (1-8th), and at a certain focus, they appear as simple as represented; and I would add, it is only when seen thus that their extraordinary motions, which differ in some respects from those of other *Oscillatoriæ*, may be clearly observed.

The motions of the *Oscillatoriæ* are indeed so singular that while some have in vain attempted to explain them as partly external and altogether physical, others are not wanting who have come to the conclusion that they must be animalculæ, solely on the strength of their apparent voluntary movements. Dr. Hassall, for instance, on the former supposition, says: "The filaments are very straight and elastic, and when they are placed for observation on the field of the microscope, they are bent out of their natural straight line, and make an effort to recover it; currents almost imperceptible in the liquid in which they are immersed, and perhaps unequal attractions, are causes amply sufficient to explain their motions." The most superficial examination, however, is sufficient to show the futility of these arguments, and I would refer the reader for a complete answer to them to a note of Captain Carmichael, which will be found in Hooker's 'Flora' under *Oscillatoria;* and I will only add that a drop of Tincture of Iodine, or an aqueous Tincture of Opium,* does neither interfere with their efforts to recover their straight line, *i. e.*, with their elasticity, nor with the imperceptible currents of the liquid in which they are immersed, but, nevertheless, puts a stop to their motions. But, before referring further to the cause of these motions, it will perhaps be desirable to define strictly in what they consist. They are, generally, not inaptly described as the oscillating of a balance with an advance in a longitudinal direction; but I must mention that sometimes these motions are slow, at others quick and effected by jerks, but the motion itself consists in the *revolving* of the filaments; they roll over and over, and forward with a sudden start and then recoil, so that their

* Exposure to the vapours of chloroform produces the same effect.

forward motion is *active* and the recoil *passive*. To observe this well, the very uppermost surface of the filaments ought to be brought in focus, leaving the margins rather undefined, bearing in mind that the filament is not a flat but a cylindrical body. As to the cause of these motions, or the mechanism by which they are effected, nothing positive is known; Dr. Kingsley has observed the whole surface of a large species to be covered with cilia, moving in a circular wave round the axis of the filament. (Mic. Journal, No. xi. p. 243.) It would be of the greatest interest to have this observation confirmed, as the presence of cilia would in a very great measure explain their motions. As a further reason for such confirmation, I would assign the fact of having discovered, as I believe, in the new species just described, a locomotive apparatus *within* the filament, independent of cilia. While attentively examining the green thread running through the middle of the filament, it suddenly vanished in one cell, and appeared more prominent in the next to it, repeatedly altering its position in different cells, now vanishing, now appearing again, without any other perceptible motion than a gentle tremor of the filament. After more extended observation the movement appeared to me to consist in a lateral deflection and retraction of the thread. If the left hand, for instance, is closed, and now the index-finger of the same hand is alternately extended and bent, if the hand is not too plump, the tendinous termination of the indicator muscle in its retraction will be seen on the back of the hand to slip to the left side, forming a curve, and to resume its former position on bending the finger. This will give a very fair idea of what I saw at that time. At last, however, having obtained a fresh supply of this *Oscillatoria*, I observed, as I have since never failed to do, in a filament of about six or eight joints, the most active size, and therefore the most fit for observation, what I consider to be its true motion. The thread suddenly began to spin round, while the filament was set in active motion, passing quickly out of the field with the corkscrew-like movement of a very active vibrio. I have said, the thread suddenly began to spin round—at least so it then appeared, though further experiments have now convinced me, that the filament itself revolves at the same time, as is the case with other species of *Oscillatoria*—but its *progressive* motion only being seen, the whirling movement seems to be confined to the strongly-marked green axis or thread which divides the cells longitudinally. I confess, on making this last discovery, the pleasure I felt on first beholding, what I could but regard as the locomotive apparatus of the filament, was greatly dimi-

nished, since the question arises, is the spinning round of the thread the *primum mobile*, the agency by which the motion of the filament is effected, or is the motion of the latter due to *another* cause, say for instance, ciliary action, in which latter case the apparent motion of the axis or thread might be accounted for by the revolving of the filament, which not being distinctly observable would have the same effect as if the thread alone spun round in propelling the filament. Still after the most careful and patient observation, I must retain my original opinion, viz., of the thread possessing independent motion, and being the cause of the motion of the filament, for the following reasons. I purposely watched and repeatedly observed, while only the most gentle oscillations were observable in the filament, the thread which was very distinct in two adjoining cells, vanish out of one and not out of the other. The gentle tremor of the filament could hardly be due to a *revolving* of the filament; but even supposing it did revolve at the time, as the thread in *both* cells was equally prominent; if its disappearance in one cell was owing to the revolving of the filament, it ought also to have disappeared in the other cell for the same reason. Similar appearances I have observed in filaments which were partly bent, approaching the figure S, and which could not have revolved around their axis without its being plainly seen; yet, as in the former instance, the thread could be seen altering its position in the different cells. As a further reason for retaining my original opinion, I will mention that by careful observation the body of the filament itself may sometimes be seen to bend simultaneously while the thread is seen to retract in the manner described above. And, lastly, though using all the best means which have been recommended by experienced observers, for the detection of cilia, I have been unable to discover any; and I would caution other observers, in looking for them, not to mistake certain appearances presented by the filaments under oblique light and an object-glass of great angular aperture, which closely resemble a fringe of cilia, though they are simply the result of the highly refractive property of the filaments.

I have been thus particular in stating what I have seen, as I am most anxious that other observers, with superior means of investigation, whom I hope to induce to verify or correct my own observations, should exactly know what I had seen; and as I have provided myself with a good stock of this interesting species, I shall be very happy to forward some of it to those who feel interested, and inclined to investigate for themselves what I consider to be a most important point in vegetable physiology, viz., the various motions observable in

plants. On this head I would offer in conclusion a few observations, in order to show that the present state of our knowledge in this respect is far from satisfactory.

Almost every day brings forth a discovery by which the old landmarks established in science for the arrangement and classification of the various products of our planet are unsettled, and this is more particularly the case as regards those two kingdoms, the lower forms of which approach so near one another, that, for want of distinctive characters, we cannot always draw a positive line of demarcation between them. This state of uncertainty, though partly the natural result of the very nature and conditions of the objects to which it refers, still prevails to a greater extent than is warranted, and must continue to do so until our present notions on this subject have undergone a thorough revision. In my opinion, the boundary assigned to the vegetable kingdom is too limited; our definition of a vegetable organism must be enlarged, and we may vindicate for plants many attributes hitherto exclusively attributed to animals, though, as a necessary consequence of the more limited sphere of activity characteristic of vegetable life in general, they will necessarily be manifested in a less prominent manner; but this should not mislead us so far as to ignore their existence altogether, and how vast a difference in the manifestation of the various attributes of life is observable even amongst animals themselves? A plant is generally defined as a natural body possessing organization and life, but devoid of sense and voluntary motion. Organization and life exclude all inorganic bodies; absence of sense and voluntary motion the class of beings which are comprised under the name of animals. Now a little consideration will at once show us how arbitrary the limits are which have been assigned to the vegetable kingdom in the latter direction. By saying devoid of sense, is meant absence of special organs of sensation, viz., nerves, and thus sensibility is at once inseparably bound up with the existence of a nervous system; sensibility, however, is simply the peculiar aptitude or capacity of organized living beings for receiving impressions, but not necessarily through nerves *only*, neither is it necessary that its effects should always be visible or accompanied by consciousness; nerves presuppose sensibility, but not, *vice versâ*, sensibility nerves. Sensibility is something *prior* to nerves; a faculty, an attribute of every living organism, but not every living organism must necessarily possess nerves; nerves are only special organs characterizing the manner of its manifestation in a certain class of beings. I would remind the reader of the well-known instances of

animals which are devoid of a nervous system, whether consisting of a spinal cord or a system of ganglions. Thus, in some of the *Radiata*, for instance, every trace of a nervous system has disappeared, yet I am not aware that they are devoid of sensibility, though without nerves. Nor would it avail much to say, though we are not able to demonstrate its existence, yet it may, nevertheless exist, as this argument would be equally applicable in reference to plants. The existence of nerves as special organs in certain classes of animals, must, therefore, be regarded as an instance of that general law which may be traced through the whole range of creation, according to which the higher we ascend in the scale of created beings, the more ample special and complex provisions are made for the manifestations of a more extended sphere of activity of individual life; the greater its intensity the more special the apparatus for its manifestations. Thus the nervous system, the most important of all, has reached in man the acme of its development as a whole, while, as an instance of special endowment, I may mention, that every hair of the beard of a cat is provided with its own separate nerve, having a special purpose to fulfil in facilitating the carrying out of a powerful instinct peculiar to this order of animals. The same relation obtains with regard to other systems of the body; compare, for instance, the beautiful mechanism of the human hand with the corresponding member of the monkey. To what a variety of complicated and intricate operations is it not well adapted in being provided with a number of muscles serving special purposes? Though the monkey can grasp a stick, he cannot perform the act of pointing, the indicator muscle being absent. What has been stated with regard to sensibility is not less true as regards irritability. If taken in the sense of Haller, as a property of the muscle, it becomes at once identified with muscularity, and in this sense, of course, no one would think of claiming it as an attribute possessed by plants; yet plants undoubtedly possess irritability, and so do many animals, which, as is admitted, are devoid of muscularity; no traces of the fibrillæ of muscle exist in the animalculæ and many allied beings, yet nature has provided a substitute, viz., sarcode, which may, for aught *we* know, perfectly supply the place and functions assigned to nerves and muscles in the higher animals. But we must go still further, and claim for plants not only sensibility and irritability, but *instinct** also.

* Taken in the sense as applied to animals, which *arbitrarily* and *irresistibly* impels them to the performance of certain actions always directed towards a definite object, conformable to their nature, tending to their well-being or propagation, *yet without their being conscious thereof*.

If plants exist without these three general attributes of life, then let me ask, in order to give but a few instances, why do we witness in many plants a kind of sleep, or exhaustion and subsequent recovery by rest? Why does the *Œnothera biennis* open its flowers only towards evening, remaining open during night, and fade the next morning if the sky is clear and bright? Why, on the contrary, does the *Drosera rotundifolia* open its flowers only under the stimulus of the strong light and warmth of mid-day? Why do the flowers of *Nymphæa alba* not only close but sink beneath the water during the whole night, and rise only the next morning above the surface? Why do the leaves of the *Mimosa pudica*, *sensitiva*, and of a number of this class of plants, visibly contract when touched? Why do the filaments of *Berberis vulgaris*, if touched on the side next to the pistil, fly immediately towards the stigma? Why do they lose this property if exposed for a short time to the vapour of chloroform? Why, indeed, does it return after a certain interval if the exposure has not been too prolonged?—(Mic. Journ., No. iii., p. 250.)

How exquisite must be the irritability of the *Dionæa muscipula*, the leaf of which, or rather a part of it, folds up, even if a little insect alight upon it? And why does it not relax its grasp but when the little prisoner has ceased to make any efforts for his delivery? Why do the five stamens of *Parnassia palustris* bend themselves forward and over the stigma, and even, *secundum ordinem*, first one, after it has risen and bent back, followed by a second, this by a third, and finally by the remaining two at the same time?

Many other instances of sensibility, irritability, and instinct observable in plants might be adduced if needed, but surely because these phenomena are witnessed only in a limited number of plants, in so striking a manner, is no reason that we should ignore them, neither can the visibility of their effects decide the question of their existence, nor is it necessary that all parts of plants should possess them in the same degree. It has already been stated that there are animals without a nervous system, without a head or distinct sexual organs; though, as a rule, the presence of a nervous system, a head, &c., forms one of the most striking characters of an animal, yet their absence, in some instances, does not *eo ipso* exclude them from the animal kingdom. In the same manner all parts of animals are not alike endowed with sensibility, as, for instance, the epidermis and other epidermal structures, as hairs, nails, &c. The other negative qualification attributed to a plant, viz., the absence of voluntary motion, appears to me equally erroneous.

As a general rule, motion, no doubt, is one of the best *zoognomic* characters, considering that the generality of plants are fixed and rooted to the soil. The idea of *loco*motion, with regard to land plants, would therefore involve an absurdity, and the motions which have been observed in them, and of which some striking instances have been mentioned, must be necessarily confined to their several parts. Under altered external conditions of vegetable existence, however, the case is different. Amongst aquatic plants, those with roots stand, of course, in the same category as land plants; others, without roots, are kept floating on the surface of the water by the construction of their leaves or other contrivances, as air-vessels (aërocystæ) for instance, such a provision being sufficient for maintaining their individual existence intact. With regard to those minute and beautiful objects, however, which are comprised under the general name Microscopic plants, quite different relations obtain, and what in the former class of plants must be regarded as a superfluity, we must here postulate as an indispensable requirement for their preservation, nay, their very existence. Take, for instance, the *Diatomaceæ* or *Desmidieæ*. Light is as indispensable to them as to the generality of plants, or as the air to us. This is an indisputable fact. Now, from their very minuteness, and the nature of the locality where they dwell, they are every moment exposed to be buried beneath the mud, and myriads are thus buried by every rising wave; they must inevitably perish if not accidentally disentombed; but a bountiful Nature has left nothing to accident as regards the preservation of her offspring, and even in this instance her own ample resources have not been withheld, for she has provided them with an ingenious locomotive apparatus, which is to them what wings are to birds—these, deprived of their wings, would certainly die of hunger, setting aside that they would be left without the means of escape from their natural enemies,—the others, without their power of motion, would perish for want of the quickening rays of light. Thus the presence of cilia, as organs of locomotion, was recognised in several undoubted vegetable organisms, which in their play had apparently so much of a spontaneous character, that it became necessary to alter the old *formula*, and v. Siebold stated that motion could only be regarded as a proof of animality, if it consisted in, or was accompanied by, voluntary contractions of the body. This was done in order to exclude the moving spores of *Algæ* from the class of animals; but, more recently, other instances have been brought forward which necessitate a further modification of this formula, and the mistake of relying for our classifica-

tions upon a single character, as though life were not a manifestation of a complicity of forces and conditions, becomes every day more manifest. If, on the contrary, the motions allowed to plants be limited to physical motions, depending upon external causes, which is the favourite doctrine of the present day, then we have no alternative left but to hand over to the zoologist many organisms, and the *Oscillatoriæ* amongst them, which, in every other respect, are of undoubted vegetable origin. Thus Mr. Hogg is in doubt whether the *Diatomaceæ* are properly classed in the vegetable kingdom, because they evince in their motions a controlling power independently of a physical force, as intervals of rest and motion may be clearly observed (Mic. Journ., No. xi., p. 235), and Captain Carmichael (Hooker, l. c.) says, "I have bestowed considerable attention on such of the species of the *Oscillatoriæ* as fell under my notice, and I do confess the result is something like a conviction that they belong rather to the animal than to the vegetable kingdom." This view of the nature of the *Oscillatoriæ* might be supported by the fact that they evolve ammonia when subjected to destructive distillation, and give off carbonic acid gas in their living state as other animals. An experiment made by me to that effect I twice repeated with the same result, the particulars of which I will briefly state, that it may be taken for *quantum valeat.* A quantity of the frothy stratum of *Oscillatoria* was put in a bottle, nearly filled with water, having its cork perforated by two glass tubes, one a straight one, penetrating nearly to the bottom of the bottle, the other a bent one, only perforating its cork, establishing a communication with the air above the mass of *Oscillatoriæ*, and another bottle, containing lime-water, on the principle of a Wolfe's apparatus. After six hours, the lime-water gave clear proofs of carbonic acid gas having passed through it.

A third experiment made under the same conditions with a mass of Confervæ gave a negative result, and thus confirmed the two former. Another circumstance worth mentioning is, that the water in which they are kept is after some time rendered slightly alcaline.* But to return to the previous question: I would observe, that it might be shown, even if it be granted that the motions of the *Diatomaceæ* are spontaneous, that they cannot on that account alone be regarded as animals, because no solid reason has as yet been brought forward why we should not admit even spontaneous motions in plants; not necessarily as proceeding from a consciousness or volition, but as simple manifestations of instinct, blind impulses of their vital force, *yet withal independent of and unconnected with any*

* At least in three instances this was the case.

external physical force. Such inferences, I admit, are not warranted by a superficial observation of external appearances, but if we penetrate deeper into the idea of life, and look for the cause of spontaneity and the proper sphere of activity of every individual living being, we are forced to attribute to every organism, possessing the general properties of life, an *animative* principle (*un principe animique*), which is the *cause* of the phenomena of life; though this internal activity of a being is not always immediately visible to the eye, still all appearances, as expressions of its individual existence, prove it to be so, and for that reason we must vindicate also for plants a *kind of soul*,* however great the difference may be which exists between it and the soul of an animal. Now, if we must admit once that certain plants are endowed with the power of motion, we must also admit that the determining cause of such motions must reside or be sought for *within* the plant itself; this would be conceding a kind of spontaneity, however limited its degree, agreeably to the narrow sphere of activity characteristic of vegetable life.

This is not the place to enter more fully into these matters, but I think I have said enough to bear out my assertion, that the present state of our knowledge on these questions is far from satisfactory, and I will conclude with referring to what, in my opinion, is calculated to retard in some measure the progress of a sound vegetable physiology. I mean the orthodox notions of certain eminent professors, and with others a kind of fear of detracting from the dignity of the genus *homo*, by being too liberal in acknowledging sundry attributes in such inferior things as plants, &c. The latter class we can pass by in silence, of the former we will give an instance. If we descend the scale of creation we come at last to a class of beings which are almost in a state of indifference, that is to say, the prominent distinguishing features of each of the two great classes of organized living beings disappear.† Now to admit such a *status indifferentiæ*, as a common starting point from which a progressive development in both directions

* Those of my readers who feel inclined to cry out "*risum teneatis*," I would refer to men like Darwin, Treviranus, Carus, and other equally distinguished men of science, who hold these opinions; see Dr. Ahrens, '*Cours de Psychologie*.'

† This is not only true as regards the two great classes of organized beings, but in some respects also as regards the sub-classes of each; thus, to give but one instance: it is still a debateable question if the *Lepidosiren paradoxa*, or *Protopterus annectens*, belong to the class of Fishes or to that of Amphibia; it possesses gills *and* lungs, in addition to fish-scales. Mr. Owen and Dr. Peters of Berlin contend for the former, Mr. Fitzinger and Professor Bischoff for the latter supposition.

takes place, has been decried by some as being unphilosophical, without, however, their offering us a better interpretation of those facts which gave rise to the proposition. In the same manner seemingly well authenticated observations, tending to establish a transition from a vegetable to an animal existence, and *vice versâ*, have been met by a similar *dictum ex cathedrâ*, which is deserving of censure, though coming from a v. Siebold or a Schleiden. Innumerable instances, from the insect world alone, might be adduced involving metamorphosis not less important as to the altered conditions of existence than would be presupposed to take place in beings of the lowest order, forming the boundaries of the two great classes, changing according to the varying external conditions from a vegetable to an animal existence, and *vice versâ*, and which might have been set aside by a similar train of reasoning, were not these phenomena from their nature capable of the most positive demonstration.

Note.

Since the foregoing was in print, further observations have taught me,—

1. That the appearances of the new species of *Oscillatoria*, indicating a transition state, are produced by the pressure of the thin glass cover when under examination. And,
2. That the alkalinity of the water in which some *Oscillatoria* had been kept is traceable to the locality from whence they came; the water being of the most filthy description, communicating with a sewer, and largely impregnated with putrid animal matter.

The existence of Mammifers *anterior to the deposition of the* Lias, *demonstrated from the* Microscopic Structure *of a* Bone *from the* River-Bed Deposit, Lyme Regis. By the Rev. J. B. P. Dennis, Bury St. Edmunds. (Plate XVI.)

Through the kindness of the President of the Geological Society, a Paper of mine was read before the Society on the 19th of March last, in which I brought under their notice certain facts which seemed to me strongly to indicate the existence of Mammifers at a period when the Lias had not been deposited, and in a deposit well known by the name of the Bristol bone-bed. Since then, through the kindness of Professor Owen, Dr. J. E. Gray, and Professor Huxley, I have had great opportunities of carrying on my investigations, and I trust that, though errors may be found in my inductions, the result of my inquiries will be found to have added some fresh truth to the treasures of science.

Being desirous of giving publicity to some of the results of my labours, the Editors of the Microscopic Journal have courteously offered me an opportunity of so doing; and as my investigations have been for the most part microscopic, that journal seems the most fitting medium for the introduction of my views.

The microscope, like the telescope in another field, has already revealed its wonders and unlocked many of the once-hidden mysteries of Nature. No small authority has said, "By the microscope the supposed monarch of the Saurian tribes, the so-called Basilosaurus, has been deposed and removed from the head of the reptilian to the bottom of the mammiferous class. The microscope has degraded the Saurocephalus from the class of Reptiles to that of Fishes." And Mr. Quekett, adverting to these brilliant results of Professor Owen, justly inquires, "Why should not the minute fragments of the other parts of the skeletons of extinct animals afford us, by the same method of manipulation, some indications of the particular class to which such fragments belong?" Such reasoning is irresistible: and I may mention as a corroborative circumstance in favour of the use of the microscope, that a geologist gave me what he considered, and what I believed to be the bone of a pterodactyle, but which the microscope proved to be crustacean.

In my examination of the microscopic structure of bone, I have observed certain facts that have induced me to suspect a law which, if I am right in the discovery, will be of great importance to science. I have noticed, for instance, in ani-

mals that have the power of springing, a preponderance of pointed, oval lacunæ, and it is curious in this respect, to compare the microscopic structure of the tiger's femur with that of the kangaroo, or the frog's tibia with that of the newt. The toad agrees very nearly with the frog, only the lacunæ are longer, a character I have observed in animals that climb. Those of the newt are quite dissimilar, and the structure of the tiger and the kangaroo is so very similar that it is difficult at first to discriminate between them. The same oval lacunæ are present in birds, and I cannot but think they indicate a power possessed by the animal, of springing. The ulna of the lesser flying opossum is a very beautiful illustration, the bone, in the shape of its lacunæ, most resembling that of birds, though still retaining sufficient evidence of the mammal in its character. The pterodactyle, that singular flying lizard, has the same pointed, oval lacunæ. The bat, also a flying quadruped, has the same; and it is curious to observe in Mr. Quekett's book that the only bird that has not similar lacunæ is the parrot, a bird that never springs from its perch, but climbs by its bill and claws. The force and rapidity with which some birds rise from the ground, as the partridge does, is perfectly surprising, and is quite as wonderful as the spring of the tiger, the bound of the gazelle, or the flight of the opossum: but the strain upon the bones of these animals must be very great, and may well account for a particular and suitable structure.

In the tarsus of a small Australian parrot, I find very few of the pointed lacunæ, but numerous long ones; and in the ulna of the same bird, the pointed ovals are much more numerous. The Arctic fox, in its leg-bone, beautifully exhibits the pointed oval lacunæ; so does the red Indian squirrel. The same may be seen in the dog, cat, common fox, mouse, &c.; and it would appear that they are present in all bones that are subject to great or violent muscular action, as a bird in its flight, or a mammal and a reptile in its bound. It is curious also to compare the leg-bone of the ornithorynchus with that of the turtle; for there is a very great similarity between them, both in the haversian canals and the shape of the lacunæ; and certainly that strange mammal does approach in its habits the chelonian.

If a very thin vertical section is taken from the same part of the humerus of a kangaroo and an otter, you will observe in the former numerous narrow-pointed lacunæ, similar to those in the tibia of the frog or in the bones of birds; in the latter you will not see one, the ovals seeming almost round. Compare the otter with the beaver, another aquatic animal, and

again you see none of the structure of the kangaroo, but a similarity in the shape of the lacunæ and the branching appearance of the canaliculi of the beaver to those of the otter; and compare both with the same bone of the newt, and though the reptilian character of the latter is apparent, there is a striking similarity in the appearance of the lacunæ. Examine a leg-bone of the ring-tailed monkey, and you will find long lacunæ more abundant than the oval; the same will be seen in the bear. These long lacunæ are very remarkable in the radius of the chimpanzee, and would seem to be connected with suspensive or pulling movements.

It is a step gained if it is found, upon comparison with the bones of different animals who possess in common some faculty, that the structure of their bones indicate it. The next step will be to discover their points of difference as well as their points of agreement with other animals. It may then be possible not only to determine, for instance, whether the animal could spring, but also whether it obtained its prey by a spring, or by bounding escaped from the destroyer. All this implies a thorough knowledge of the microscopic structure of the bones of animals from observations made in different parts, and exact comparisons made with the same bones in different animals; and until this has been done, no satisfactory conclusion, in this respect, can be arrived at. If, however, there is any appearance of truth in this opinion, it is for the mathematician to show what effect the difference of shape in the lacunæ may have upon the strength and uses of any particular bone. It may be only the sportive fancy of Nature, as she has delighted to besport herself in the varied structure of the foliage of plants; yet if that sportiveness has only method and arrangement, it may prove of admirable use in distinguishing animals by the microscopic structure of their bones, as plants already have been by that of their leaves. In the fragment of a bone, what clue can we have to the character and habits of the animal to which it once belonged, unless the microscopic structure indicates it. As far as I have been enabled at present to carry my investigations, everything has tended to show that there is a singular correspondence in the microscope structure of animals of similar movements. This matter, indeed, is well worthy of investigation, since if any indication of habits may be deduced from the formal arrangement of the lacunæ, we shall be able to reconstruct, in some degree, the history of a primæval animal, of which only a fragment of its bone remains.

The presence or absence of haversian canals are no proof for or against a bone being mammalian, as the radius of one of

our common bats does not exhibit* them, not to mention other instances In the thick portion of fig. 2, Pl. XVI., there are apparent traces of haversian canals which very probably have been ground away in the more transparent portions of the bone, a circumstance of frequent occurrence in grinding vertical sections of fossil bone. Figs. 2 and 2 *a* show admirable lacunæ that are in connection with an haversian system, and very nearly compare with that of the walrus, fig. 8.

Having made these preliminary observations, we will turn at once to the consideration of the fossil bone, of which fig. 1 is a representation, and attempt to determine its true relations. If by the microscope alone it may be shown to be possible to assign it its due position in the scale of animated beings, the achievement will be a brilliant one; if failure ensues, at least it should be pardonable. Figs. 2 and 3 represent small vertical sections taken from the lower part, and magnified 100 diameters. Figs. 2 *a*, 2 *b*, portions of fig. 2, magnified 400 diameters in fig. 2 *b*, the lacunæ are irregular, and agree, in this respect, with some of the three-toed sloth. The upper end of the bone is composed of fine cancellated structure: the appearance externally is very fine in the grain like ivory. The bone came from the bone-bed deposit west of Lyme Regis, which rests upon the upper beds of the new red sandstone, and is identical with that deposit which has been called—from, I believe, the circumstance of its first having been observed at Bristol—the Bristol bone-bed. It is principally composed of minute portions of bones and fishes' teeth, and was supposed chiefly to contain the remains of fishes.

For convenience sake, I shall refer at first to Mr. Quekett's very excellent histological work; and we have to deal therein with Fishes, Reptiles, and Mammals, for Birds may well be put out of the question. None of the plates on Fishes demand our notice, until we arrive at Plate V., and this requires attention. At once we may dismiss the *Lepidosiren*, as the size and shape of its lacunæ, not to mention other differences, forbid us to compare our fossil with it; no more can the *Megalicthys Hibberti*, figs. 1, 2, 3, 4, and 5, be compared with it. We may also dismiss the figures of the Burdie house fossil, for the lacunæ of that sauroid fish more nearly agree with those of the pterodactyle. We have now only the supposed *Rhizodus* to deal with, and a very slight examination of figs. 16 and 18, the transverse and vertical sections of the cranium with the plate, will show at once that no agreement exists

* At least at present I have not detected any. They are hardly apparent in the rib of the rat, and wanting in the scapula, &c.

between them, either in size, shape, or number of the canaliculæ. Nor do we meet with better success in viewing the plates on saurians: most of them much exceed the fossil in the size of their lacunæ, and those that do not, differ in form. We are therefore obliged, so far as Mr. Quekett's book is concerned, to turn to his plates on Mammals, when at once we cannot help noticing a striking similarity, especially when we come to the sloth, and even more so when we reach Plate XI., and find ourselves amongst the cetaceans. The mammalian characters of the lacunæ and canaliculi of the fossil in question, are certainly unquestionable; and besides this, there is a very striking similarity in them to those of the edentata and cetacea.

I shall now attempt the proof from my own practical observations; and let me here observe, that if any person wishes to make himself acquainted with the structure of bone, the best way is for him to do as I have done – grind for himself every bone he can lay his hands on. It is a matter more of time than of difficulty, except in the manipulation of fossil bone, which requires all the care imaginable. Above all, let him not put recent bone near Canada balsam, as all the minute structure of bone is destroyed by it, unless polarised; and even the canaliculi and lacunæ are filled with the balsam, and often obliterated. Old or burnt Canada balsam should be used when any is required, as is the case often in fossil bone, when the canaliculi require to be better exhibited; and as the small passages of fossil bone are generally filled up, the balsam, of course, cannot then enter, while it has the advantage of making other parts of the bone more transparent.*

Some of the fossil fishes with which our bone was a contemporary were remarkable, some for the massive character of the scales, and others the armature of their jaws. Through the kindness of Mr. Adams,† a gentleman residing at Buriton, Petersfield, and who has in his cabinet some interesting Stonesfield fossils, I have been enabled to examine the structure of the jaws of the *Lepidotus* and *Pycnodus*: the structure of the former tubular, something like the fistularia; the latter I have figured, as its lacunæ and canaliculi well illustrate the icthic characters when they are present in fish, which are as follows:—lacunæ of irregular shape, often stellate; canali-

* I have obtained the best sections by the aid of marine glue.

† This gentleman has also enabled me to figure a fossil saurian from Stonesfield, fig. 5; it compares almost exactly with the crocodile (*vide* D and E of Plate), and is well worthy of notice from its showing that nature has not deviated from her primeval plan.

culi *few in number*, rather thick at their bases, tapering off, branched, straggling, reticulate.

I have examined other fossil fish, as the *Dapedius* and others, but could find no appearance whatever of lacunæ or canaliculi in their structure. One, a very powerful-boned fish, that I found myself at Lyme Regis, and which I believe is at present undescribed, is entirely destitute.

In the skull of the *Pagrus*, a recent sparoid fish, whose jaws are armed with a most formidable array of canines and molars, I have not been able to discover a vestige, either of a lacuna or a canaliculus; and this I should presume applies to all the class. The sturgeon only shows them in its fin-bones and dermo-skeleton, where the lacunæ are very thick together. Other large fish exhibited none. Our common roach has them in the ribs. When, however, they are present, as in the conger-eel, sturgeon, &c., they present precisely the same characters, especially the *very small number of canaliculi*, and their straggling, spider-like character. There is nothing whatever to show that the bone under our consideration, as the slightest examination of the figs. 21, 22, tells us, ever belonged to a fish, for the lacunæ and canaliculi have no icthic characters. The contest, therefore, runs between saurians and mammals; but I think I can satisfactorily show that there are certain marked characteristics between the lacunæ and canaliculi of mammals and reptiles, and that in these the fossil agrees with mammifers, though certain higher saurians do approach the lower mammifers in apparent similarity, as might be expected; and much more irregularity of structure is observable in the bone of the walrus or dugong than we observe in the cat or giraffe.

There are certain well-marked and distinctive differences in the lacunæ and canaliculi of Reptiles and Mammals; and which, when made apparent, render the task easy in determining the question about a fossil bone, if its structure is sufficiently preserved so as to show some of the lacunæ with their canaliculi pretty perfect and well-defined.

The lacunæ in Reptiles are more generally irregular in their shapes; and by this I do not mean that irregularity which is observable in some mammifers, where the lacunæ are some long, others oval, while some are nearly round; for a regularity is observed in one sense, as far as the individual shape of a particular lacuna is concerned; but in the reptile the lacuna is more often irregular in its shape. We must be careful, however, not to confound a transverse or tangential section of an haversian canal with a lacuna. The crocodile, which of all reptiles that I have observed, ap-

proaches nearer in the general appearance of its lacunæ to mammals, having its lacunæ much more regular in form, is still not free from the reptilian character. Great caution, however, is required, as the walrus, and other lower mammals, are inclined more or less to an irregularity in this respect.

The canaliculi of lizards are in general thicker than those of mammals, and do not branch, but run in wavy courses from the lacunæ, where a number interlace. They have something of the appearance of trellis-work. In the boa-constrictor the saurian characters of the canaliculi are well displayed, which more or less are apparent in all saurian bone that I have examined. The canaliculi also are much less numerous, though their number varies in different Saurians. The definition, therefore, of the general character of the lacunæ and canaliculi of Saurians will be:—lacunæ more generally irregular-shaped generally larger than mammals; the canaliculi generally larger, in a similar manner extending from all parts, not so branched, long, thick and wavy. There are apparent exceptions, of course, to this general definition; but in the main it is truthful and correct. The irregularity of the lacunæ in Reptiles sometimes gives the appearance of branching; but then a thinner part of the lacuna is mistaken for a canaliculus. I have observed this in the boa-constrictor.

In examining mammal bone, the lacunæ are observed generally to be (whether they are round, oval, or long and fusiform) of a pretty regular and uniform appearance, especially in the higher mammifers, and are generally of an oval character. They are also smaller than the generality of Saurians.

The canaliculi are *much more numerous* than those of Saurians, and often *fork out at their base;* and besides this, *give out branches.* One end of a lacuna, when viewed with its long axis, generally looks something like the head of a stag's-horn beetle, the canaliculi being bifid, and branched like antlers. In most of the lacunæ of the crocodile, I have observed the greatest apparent approach to this character; but it is more an apparent one (*vide* lacuna D). In the mammal there is a considerable open space often left where the extreme canaliculi bifurcate; whereas in the crocodile they simply radiate all round, with little or no bifurcation, or run out into a long point. The mammal definition will then be:—lacunæ generally of regular form, most frequently oval, bifurcate, with forked, branching, fine and numerous canaliculi.

These remarks and definitions refer to *vertical sections*, and the lacunæ are defined as they appear when seen with their *long axis in the field.* Transverse or tangential sections give the lacunæ always a more or less irregular form, and the la-

cunæ generally are then presented with their short axis in view. The mammal that shows most irregularity in its lacunæ, as far as I have observed, is the walrus, and perhaps the dugong. The definitions given appertain only to those lacunæ that appear in the haversian interspaces. Those that form part of an haversian system have uniform and nearly straight canaliculi proceeding from them, which in the mammal generally are *more numerous and finer, and less wavy than in the Saurian.*

The lacuna, fig. 4, is most remarkable for the great number of canaliculi proceeding from it; and from a photograph that I have of it, they appear so numerous, that they are not distinguishable one from the other. Figs. 2, 2 *a*, beautifully exhibit some of the lacunæ in the fossil connected with an haversian system, and very clearly show their mammal character.* They bear a close comparison with the walrus; and since that comparison is made with the recent bone of a mammal, it is easy for any person who knows something about the microscopic structure of bone, to form an opinion as to whether I am right or wrong. For my own part, I cannot entertain a doubt upon the question as to the bone belonging to some lower mammal. But, at any rate, a new field is opened for the microscope; for the question I have raised must have a fair and scientific solution. For if we are not able to discover the bones of mammals and birds (and why we should not discover them I know not, especially as the footmarks of the latter have been already noticed), we shall at least be able to add new genera and species to our existing list of reptiles and fishes.

The Bristol bone-bed is a mine of animal matter. Let only the microscope, with its splendid powers, be scientifically used, and it must bring to light new treasures for science. In investigating these matters, one thing ought ever to be borne in mind, and which I have already adverted to—the connection or relation that the bone bears to the animal to which it belongs. If this is not considered, I think our inquiry is almost useless. We want not only to say that such a fragment of bone belongs to a mammal or a fish, but we also desire to be able to discover something of the general character of the animal to which it belonged.

In forming our judgment, then, concerning this or any other fossil bone by its microscopic structure, we must do pretty much what an anatomist would do under similar cir-

* I had intended that fig. 2 *a* and fig. 8 should have been magnified the same number of diameters; the correspondence then would have been more striking: but the reader must bear in mind that fig. 2 *a* is magnified twice as many times as fig. 8.

cumstances, in determining about a particular bone or tooth; that is, try to discover the class and order of animals it most resembles in its general characters. As I have adverted to before, great variety is observed in form and position of the lacunæ in the bones of animals; the canaliculi also vary. Having first of all determined the class, by a strict comparison with known forms, then an attempt should be made to form a judgment of the kind of animal, based upon inductive reasoning, the result of numerous and accumulated facts; and unless we study recent bone with this end in view, we shall only half do our work. It is a matter of difficulty, no doubt, and the subject is quite a novel one; but it affords most interesting material for microscopic inquiry.

Too great praise cannot be given to Mr. Tuffen West for the extraordinary accuracy of his engraving. He says, and truly says, *that each lacuna, with each of its canaliculi, is a study from nature,* and though I see my name at the foot of the Plate, yet I beg to say that all I have had to do with it was in some measure to design its form, and to give Mr. West the sections of bone to engrave from. I left them in his hand to be produced in their truth and perfectness, and most admirably he has accomplished the work. I ought to mention that, for the sake of ready comparison, some fossil and recent sections of bone have been introduced into the Plate. They are as follows: A, single lacuna, with its canaliculi, human; B, tiger's; C, boa constrictor's; D, crocodile's; E, fossil saurian's, Stonesfield; F, turtle's, G, conger-eel's: these I term typical. Fig. 19, crocodile, transverse section. Fig. 5, Stonesfield, fossil saurian. Fig. 9, fossil vertebra of a whale. Fig. 7, fossil mammal, probably a palæotherium; tertiary strata, Touraine. Fig. 20, toad. Fig. 21, fin of sturgeon. Fig. 22, fossil fish, pycnodus, Stonesfield. Fig. 10, fossil mammoth, Till. Fig. 11, ant-eater. Fig. 12, three-toed sloth. Fig. 15, ant-eater, vertical section. Fig. 16, sloth, ditto. Fig. 13, dolphin, ditto. Fig. 14, dugong. Fig. 17, dolphin, vertical section. Fig. 18, dugong, ditto. Figs. 1, 2, 2 *a*, 2 *b*, 3, 4, and 6, representing the fossil in question.

On the presence of MICROSCOPIC FUNGI *in* WATER *deleterious to Health.* By EDWIN LANKESTER, M.D., F.R.S.

NOT one of the least important services rendered by the microscope, is the facility with which the presence of organic matters, especially when living, can be detected by its agency in positions where chemical analysis fails to recognise such compounds at all. This is remarkably the case with the lower forms of animal and vegetable life which inhabit fresh, mineral, and marine waters. Some of the animals, as, for instance, the jelly-fishes, which are large enough to be seen by the naked eye, and even to present creatures of formidable dimensions, are scarcely recognisable by chemical analysis in the water in which they have existed. Such facts as these seem to indicate that the microscope may be successfully employed in investigating waters which may be suspected of containing deleterious matters, or of determining the presence of agents injurious to health. It is true that our knowledge of the forms of microscopic life which may be injurious to health is very limited, but sufficient is known to stimulate further inquiry, and to prompt further efforts to identify special organic forms with the unfitness of water for dietetical purposes. On this ground I have thought the following notes not unworthy of record.

In the autumn of 1854, I was requested to examine the well-waters in the parish of St. James's, Westminster, as some of them, not without reason, as it subsequently turned out, had been suspected of communicating, or predisposing those who took them to, attacks of cholera. At the time I examined them (October, 1854) the majority of these waters presented no organic peculiarities. One of them, however, that in Broad Street, Golden Square, and which was afterwards proved to have been remarkably connected with the great outbreak of cholera in the parish of St. James's, in September 1854, presented, after standing a little time, a cloudiness visible to the naked eye. On examining a few drops of this water with a $\frac{1}{4}$ inch object glass, the cloudiness was seen to be produced by the flocculent mycelium of a fungus (Pl. XIV., fig. 16). On one occasion, whilst examining this mycelium, I observed a distinct passage of small oval bodies, of varying size, which passed on from one branch to another, and presented an appearance closely resembling the movement of the blood globules in the capillary vessels (fig. 17). This movement continued for several minutes. Although I looked for this movement again several times, I was never able to observe it, and the fungus shortly after this time was not developed in the water.

This fungus produced a sporidium (fig. 18), which was at first filled with closely-packed spores; after a little time they

exhibited a movement similar to that seen in the spore cases of *Achlya prolifera*, and eventually burst the spore cases, and became distributed by their movements through the water.

In a communication from Mr. Currie on this subject, he says: "The circulation in the mycelium of Fungi would be a novelty, but you are probably aware that there are many *Algæ* in which moving bodies similar to those in your fig. 17 have been observed, and it is a question whether these bodies are the produce of the *Algæ* themselves, or whether they are the motile spores of aquatic Fungi which have forced their way into the cells of the *Algæ*." The bodies moving in the mycelium of the fungus were much smaller than the spores which escaped from the spore-case.

Since the occurrence of the above my attention has been drawn to the production of a fungus in well-water by Dr. Daubeny, of Oxford. The well was situated at Cirencester, on the premises of Mr. Robert Brown, wine-merchant. His son-in-law, Mr. Pooley, who communicated the facts to Dr. Daubeny, lived on the premises, and with his family was in the habit of using the water for washing and drinking purposes. Mr. Pooley's family had suffered much from illness, and one child died. Mr. Pooley says: "My attention was first called to the question of the water by Mr. Warner, who, from the rapid and fatal symptoms in my little girl, and the occurrence of the same symptoms in the rest on their return to the house, suggested the possibility of the cause residing in the water." The water, although before suspected, from being "bright and inodorous," had not been regarded as the cause of the family illness. It was now, however, again investigated, and Mr. Pooley states, in a letter to Dr. Daubeny, that having a fortnight previously filled an eight-gallon zinc cistern with the water, on going to examine it he found "the surface covered to the thickness of half an inch with a gelatinous opalescent cake."

"The water was analyzed by Dr. Voelker, who found its chemical constituents to be, in two imperial pints evaporated to dryness in water bath, and residue dried in air bath at 300° F.

	Grs.
Inorganic substances	6·94
Organic matter	0·37
	7·31 grains.

"Dr. Voelker considered, as far as it was chemically concerned, that the water was a wholesome drinking water. I then submitted it to the microscope, and Mr. Terry's report is as follows :—

"'*General Hospital, Bath.*

"'I have been able to discover no trace of sulphuretted hydrogen nor ammonia in the water. The fresh water under the microscope gives

evidence of much vegetable growth (Fig. 19), and also a large number of minute points, which, on the water being exposed to the action of the air in a warm room, for three days, became exceedingly lively animalcules, which move so rapidly over the field of the microscope that their exact form cannot be defined, but appear to be of an oval, flattened shape, somewhat like the sole, and are not quite one-thousandth of an inch in length.'

"Professor Buckman's microscopic observations exactly coincide with the above, except that he has not found animalcules. His drawings are similar. He says, the water contains an abundance of fungoid growths, and from the fact of their requiring nitrogen for their nourishment, he is of opinion they must obtain their supply from some communication with a neighbouring cesspool. He concludes their presence is sufficient to account for almost any amount of mischief.

"Dr. Britten, of Bristol, observes, 'I find a few filamentous confervoid filaments, with sporules and sporangiæ developed upon and around empty decomposing spore cases.'

"My own observations, repeated a great many times, confirm the above, with this addition, that besides the growths already mentioned, the great bulk of the fungus is a prolongation of hair-like tubes, twisting and decussating in every direction, so as to form a tangled knot, like a skein of floss silk in a tangle."

It is quite impossible to refer the loose flocculi (fig. 19) found in this water to any particular species of Fungi. The interest of the facts stated above consist in their probably indicating a condition of the well-water injurious to health.

With regard to Professor Buckman's theory that the well at Cirencester probably communicated with a cesspool, I may add, that the well in Broad Street, in which the fungus first described was found, was subsequently proved to have communicated, by a broken drain, with a cesspool in a neighbouring house.

Further OBSERVATIONS *on the Genus* TRICERATIUM, *with Descriptions and Figures of New Species.* By T. BRIGHTWELL, F.L.S.

IN June, 1853, I communicated to this Journal a paper on the genus *Triceratium*, with descriptions and figures of 22 species. Since that time, I have used my best endeavours to add to my knowledge of these singular forms, and have nearly doubled my list. Those not before described I purpose to describe in this paper, adding figures of each species, and shortly to notice such as other labourers in the same field have made known. I take this opportunity, also, to correct some errors in my former paper.

The species described and named by me *T. brachiolatum* I conclude (since I have seen Ehrenberg's fig. in his 'Microgeologie') to be his *T. pileolus*. See 'Microgeologie,' Pl. XXXV. A. XXI. fig. 17.

Mr. Shadbolt's *T. arcuatum* (See 'Trans. Mic. Soc., Vol. II. p. 15, Pl. I., fig. 5') comes also very near the same species, if it be not identical with it.

T. comtum? Ehr.—This species has recently been added to the British Fauna, by Mr. Roper. See 'Mic. Journal,' Vol. II. p. 281. I have in my paper erroneously referred to Kützing's species *Algarum* for this species; but the only notice I find of it is in the last edition of Pritchard's 'Infusoria,' where a description is given, I presume from Ehrenberg, but it is marked doubtful, and I perceive by Professor Smith's recently published 2 vol. 'Brit. Diatom.,' he is not satisfied that it is distinct from favus.

T. favus.—I have lately received a small gathering from Sierra Leone, abounding in this species; and among the frustules I have detected two of a cubical or square form, of which I have given a figure. This variety is of great interest, as confirming those discovered in two other species of *Triceratia*, described and figured in my former paper. These varieties, and the singular and bizarre forms into which another species hereafter mentioned runs, show a tendency in the frustules of this genus to vary from the regular form.

In a letter I have received from Professor Bailey, he says, that although he leans to my opinion that these 4 and 5-sided forms may be varieties of the triangular ones, he is not yet fully convinced that this is the case. *T. favus* is, he says, abundant on their coast, and he has seen it by thousands at least, yet not one 4-sided or 5-sided one occurs; while in South America, where the same species is equally abundant, a species with 4 sides, which he refers to *Amphitetras* for the present, occurs with *T. favus*, and resembles it closely in its markings. The 4-sided forms having now been met with in connection with three distinct species, will, we think, go far to establish them as varieties. The projection of a connecting membrane beyond the suture of the valve, which is one of the characters of the genus *Amphitetras*, is not seen in these square forms.

The fine species discovered by me, and which in my former paper is described as *T. striolatum*, Ehr, appears to be new; and my *T. membranaceum* to be *T. striolatum*, Ehr. See Mr. Roper's paper 'Mic. Journal,' Vol. II. p. 8, Pl. VI., fig. 3. Mr. Roper's description and figure of *T. striolatum*, Ehr., will be found to agree with my *T. membranaceum*, so as to leave no doubt of their being the same. The species described by me in my former paper as *T. striolatum*, I propose now to call *T. formosum*, a name peculiarly applicable to the fine frustules of this large and beautiful species.

Synopsis of new Species.

Section I. Sides concave, with angles protruded. Valvular cells, minute.

1. *T. exiguum*, Smith; Smith's 'Brit. Diat.,' vol. ii., p. 87, No. 17.—This very minute species, the only one hitherto found in fresh water, has been long known to the microscopists of this neighbourhood. It occurs in fresh water at Ormesby and Horning, in this county, where it is not uncommon.

Plate XVII., fig. 1 *a*, *b*, *c*, end views; *d*, front view.

2. *T. brachiatum*, n. s.—Angles drawn out into short thick arms, bluntly truncated, and separated from the body by a distinct transverse canaliculum.

Barbadoes earth. Plate XVII., fig. 3 *a*, *b*, *c*, showing variations in size and breadth of arms.

3. *T. truncatum*, n. s.—Like the last; but larger and stouter, and having the surface of the frustule separated into twelve or more divisions, by distinct lines or canaliculi, running horizontally from an irregular central line, or canaliculum.

Barbadoes earth. Plate XVII., fig. 4.

4. *T. venosum*, n. s.—Larger than the last. Sides concave, ends rounded off. Canaliculi numerous, emanating from a central point in the frustule, and diverging into two rows of irregular divisions on each side.

Barbadoes earth. Plate XVII., fig. 5.

5. *T. coniferum*, n. s.—Sides of the frustule irregularly concave; the angles being drawn out into an extended cone, recurved towards the end, with a short stout horn near each end. Centre of the frustule convex, with three stout setæ; one placed towards each angle.

Shell cleanings? Plate XVII., fig. 6 *a*, end view; 6 *b*, front view.

Section II. Sides straight, or somewhat convex. Valvular cells, varying in size.

6. *T. favus*, var. β.—Cubical, four-sided, the sides somewhat concave, and each of the four ends terminated with a stout horn.

Sierra Leone; mouth of River Rohelle. Plate XVII., fig. 7.

7. *T. formosum*, var. γ.

Bermuda earth. Plate XVII., fig. 8.

I deem this to be the same variety as that found with the recent frustules. The occurrence of such a form in a fossil or deposit state, has induced me to give a figure of it.

8. *T. armatum*, Roper. 'Mic. Journal,' vol. ii., p. 283, fig. 1.—I possess several forms from different localities, nearly allied to, or perhaps, varieties only of this species. The figure in the 'Mic. Journal' being unsatisfactory, I have given front and end views of British specimens.

Neyland, near Haverfordwest. Plate XVII., fig. 9 *a*, end view; 9 *b*, front view.

9. Var. α.—Stout, and more convex than the British species; valve studded with numerous short spines, horns short and stout.

Algerian deposit. Plate XVII., fig. 10.

10. Var. β.—Smaller than the last; but like it in form, having three spines on the surface of the valve, one on the middle of each side.

Australia. Plate XVII., fig. 11, an end view; 11 *b*, front view square variety.

11. Var. γ. Frustule not only with numerous short spines, as in var. α, but having numerous long and stout horns proceeding from the surface of the valve.

This last has more the aspect of a distinct species; and if so, I propose to call it *T. horridum.*

Algerian deposit? Plate XVII., fig. 12.

12. *T. marginatum*, n. s.—Frustule surrounded with a broad margin or frame, having transverse canaliculi, and two large circular cells at each angle. Surface of the margin with small circular cells, and of the centre with small radiated cells.

Plate XVII., fig. 13.

13. *T. radiatum*, n. s.—Frustule large, surface undulated and depressed in the centre, covered with minute puncta or cellules, arranged, as in *T. condecorum*, sides nearly straight, angles sharp, but without cornua or horns. Short radiated lines proceed from the centre, outwards, and from each of the sides inwards.

Barbadoes deposit. Plate XVII., fig. 14.

14. *T. tabellarium*, n. s.—Margin of the frustule thickly studded with small cells, indented along the inner side in foliaceous curvatures; surface of the frustule spotted with small patches of cells. Angles with small cornua or horns.

Honduras. Plate XVII., fig. 15.

15. *T. hyalinum*, n. s.—Small, transparent, surface with very minute dots or cells, sides regular and straight, angles without spines.

Barbadoes. Plate XVII., fig. 16.

Section III. Ends of the angles entirely rounded off.

16. *T. Marylandicum*, n. s.—Surface of the frustule covered with numerous delicate finely-punctured parallel striæ or lines, radiating from a central pseudo nodule—a stout short spine placed laterally near each angle, and in some frustules a spine also in the centre of each side; sides nearly straight, with the ends clean rounded off.

Maryland deposit; P. Bailey.

Fragments of the frustules of this singular and beautiful species are common in this deposit, but perfect ones are rare.

Plate XVII., fig. 17.

17. *T. punctatum*, n. s.—Surface covered with large cell-like puncta, suddenly diminishing in size at the rounded angles; frustules somewhat stout. This species varies much in size, and in the stoutness of the puncta.

Arctic Regions. Plate XVII., figs. 18 *a*, 18 *b*, 18 *c*.

18. *T. variable*, n. s.—This species resembles *T. alternans*, but is larger, and has not only three lines, as in that species, but an indefinite and variable number of other lines, upon the surface of the frustule. The angles also are prone to run out into bizarre and ever-varying forms, giving a grotesque appearance to the frustules.

Peruvian Guano, and in slides, from Mr. Topping, marked "Infusoria Gomara." Plate XVII., figs. 19 *a*, 19 *b*, 19 *c*.

19. *T. parmula.*—Minute, frustules thickly punctate; sides convex, with small projecting papillaform angles, the outline of the frustule resembling a little shield.

Port Natal, South Africa. Plate XVII., fig. 2.

20. *T. orbiculatum.* Shadbolt, see below, Pl. XVII., fig. 20, *a. b*,

New Species described by other Authors.

Mr. Shadbolt has described four new species from Port Natal. See 'Trans. Mic. Soc.' Vol. II. p. 15.

1. *T. sculptum.* 'Trans. Mic. Soc.,' Plate I., fig. 4.—A fine specimen of this singular species has occurred in a gathering received by me from Wairau, New Zealand.

2. *T. arcuatum.* L. c., Plate I., fig. 5.—Qu. *T. pileorus,* Ehr.? See ante.

3. *T. orbiculatum.* L. c., Plate I., fig. 6.—I have detected frustules of what I take to be this species in shell cleanings; and have seen slides of the same from the Mauritius, marked *T. ocellatum?* Ehr.; but they by no means agree with Ehrenberg's specific character of that species—"lateribus leviter concavis, cellulis inequalibus mediis maximis hexagonis." Mr. Shadbolt's appears to me a good species, and appropriately named. I have given a front and end view, to afford an opportunity of determining the species.
Plate XVII., fig. 20 *a*, end view; fig. 20 *b*, front view.

4. *T. contortum.* L. c., Plate I., fig. 7, *a, b.*—This singular and interesting species has some affinity to my *T. coniferum,* but is quite distinct.

Professors Harvey and Bailey have described four new species. See 'Mic. Journal,' Vol. III. p. 94. No figures are given.

1. *T. concavum.* Hab. Tahiti.
2. *T. gibbosum.* Hab. Tahiti.
3. *T. orientale.* Hab. Mindanao.—The description exactly agrees with that of *T. grande,* in my former Paper. See vol. i., p. 249; Plate IV. fig. 8. I conclude they are the same.
4. *T. Wilkesii.* Hab. Paget's Sound.

Professor Bailey has also described and figured another new species.

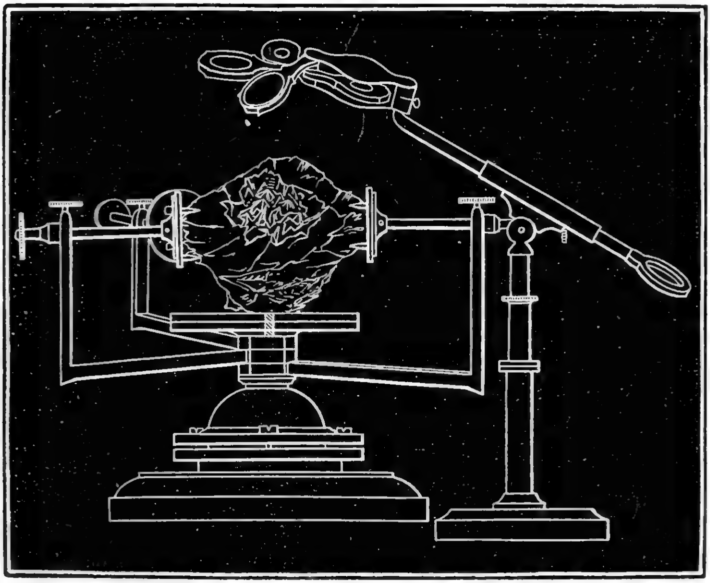
T. setigerum. 'Smithsonian Contributions to Knowledge,' Feb. 1854, p. 11, fig. 24. Tampa Bay, Florida.—This species, Professor Bailey says, appears to be allied to his *T. spinosum,* and both these species appear to me allied to my *T. tridactylum,* and to *T. armatum,* Roper. I incline to think they are all one species, and in that case should be called *T. spinosum.*

Contributions to Micro-Mineralogy. By Samuel Highley, F.G.S., F.C.S., &c.

Part I.—*Instruments of Micro-Mineralogical Research.*

For the preliminary inquiry as to the general features of a mineral mass, I arranged an instrument that should allow of its free movement in all directions, and that might be left in any position during a prolonged or interrupted examination by means of the ordinary hand or pocket lens; this is delineated in fig. 1, by which its construction will be readily understood. To a firm base a ball-and-socket motion is attached; from the upper part of the ball arises a circular stem on which fit three right-angled arms, capable of rotating round their axis to any position, and then being clamped by a broad circular stage that screws on to the axial stem; through the top of each arm a square rod passes, likewise capable of being clamped at any point by little nuts; on the end of each rotates a disc, studded with three pins, which may be used naked or clothed with corks, according to the nature of the

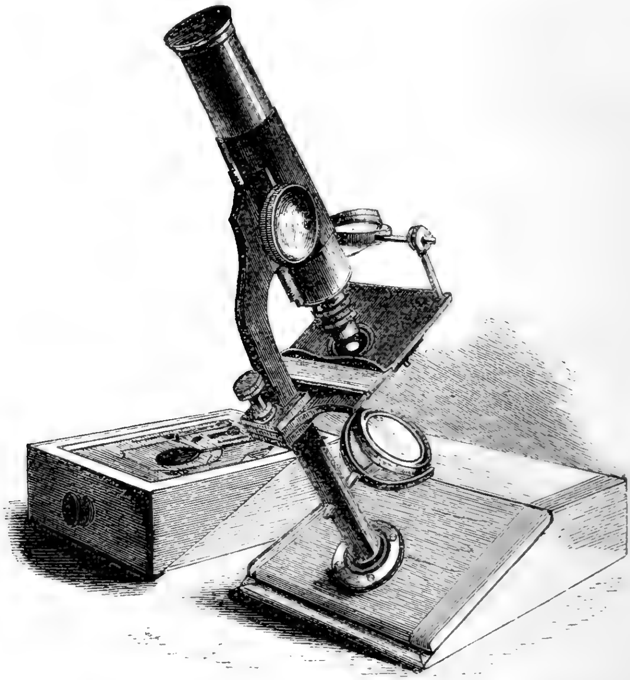
Fig. 1.



body under examination: a telescopic universal movement-stand for the lenses completes this arrangement. The stop-

plate of the lenses may be conveniently fitted with a small moveable Tourmaline analizer. A stouter stand and stem, carrying a Leeson's or Schmidt's goniometer, may be used in place of the lens, for measuring the angles of large crystals.

Fig. 2.



As a Laboratory Microscope is subject to rough usage, an economical form is certainly desirable; the instrument, fig. 2, I contrived to this end. It is of a good size, substantial and neat-looking, has a rack-work movement to the body, bulls-eye condenser, with universal movement, and packs into a case 8 inches by $6\frac{1}{2}$ and $2\frac{3}{4}$ inches deep; the whole being purchaseable under three pounds. When the drawer is in the case, the instrument is upright. I have adopted a novel mode of bringing it into the inclined position in the cheapest way, by cutting the sides of the box away to a convenient angle, so that, when the drawer is removed, half of the top of the box, being hinged, falls to the incline, as shown in fig. 2.

For convenience in prosecuting the inquiries here laid down, I deemed it necessary to construct an instrument that

should be applicable, not merely to microscopical, but to chemical and physical examinations, and that should combine in one, the principles of Nachet's Chemical Microscope with those of Soleil's Polaroscopes for the measurements of the optic axes, circular polarization and saccharimetry, Darker's Selenite stage, Kobell's Stauroscope, Leeson's and Wollaston's goniometers, Jackson's micrometer, with the means of determining the Indices of Refraction in minute crystals, &c.

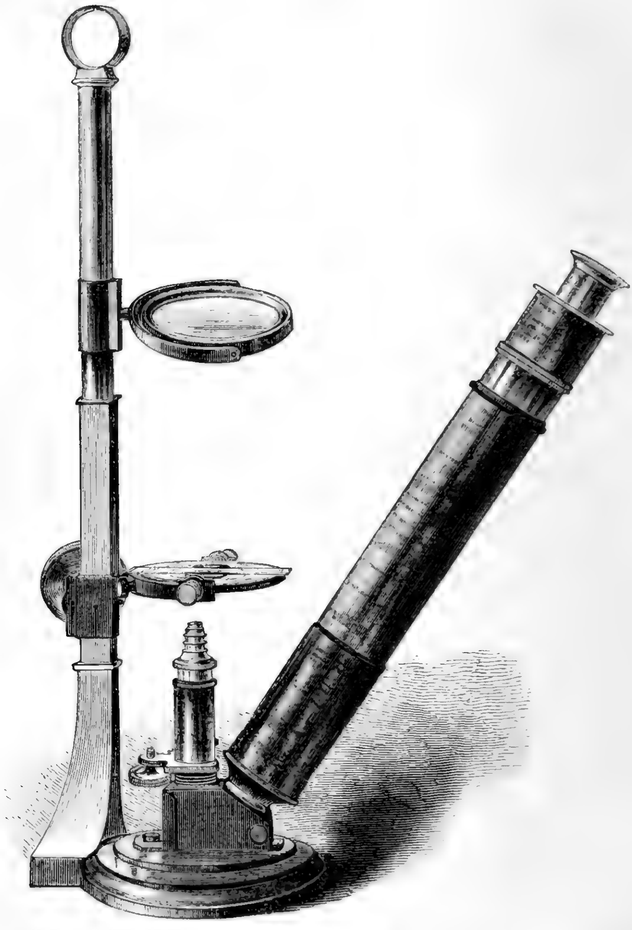
The instruments known as Nachet's Chemical Microscope since the Exhibition of 1851, and figured in the edition of Professor Quekett's Treatise of that year, has been claimed by Professor J. Lawrence Smith, of the University of Louisiana, U. S., as his invention, who seems wrath with M. Nachet for not having mentioned his name in connection with the instrument, and with Professor Quekett for not knowing, what I believe few others knew till the appearance of his article in the September number of Silliman's Journal for 1852, wherein he states that this form of instrument he invented in 1850, and brought under the notice of the *Société de Biologie*, of Paris, in the month of September of that year, and with improvements in the micro-metrical parts before the American Scientific Association in 1851. Those who are acquainted with the wholesale way in which the MS. descriptions of Exhibitors' articles were, in most cases as a matter of necessity, cut down to occupy the least possible space in the Official Catalogue of the Great Exhibition, will not, perhaps, think M. Nachet the one to blame that Professor J. L. Smith's name did not appear in connection *with the single line** that records the appearance of this Microscope at the World's Fair. Or can Professor Quekett be fairly blamed, if with many calls upon his time, he does not read every foreign journal that may issue from the prolific Continental press, or that he did not become acquainted with the proceedings of the American Scientific Association for 1851, before he issued his edition of December in that year, considering that, like our own British Association, it does not publish its Reports *immediately* after its adjournment; or that he should not have known that Messrs. Wartz and Verdiel had that form of instrument in use at their laboratory *in Paris*, especially as Professor Smith states that *only mention* was made in the *Minutes* of the Societies referred to, and that *no published account* of his principle had been given to the world.

Curiously enough I first became acquainted with this prin-

* See Descriptive Catalogue, vol. iii., p. 1242, No. 1370; also Juries' Reports, p. 267.

ciple of Microscope in 1850 through Dr. Leeson, who, during *the summer months* of that year, had his large Microscope altered by Messrs. Smith and Beck to the form claimed by Professor Smith, for the purpose of prosecuting, during the winter months, some micro-crystallographical researches; and

Fig. 3.



on lately referring to Messrs. Smith and Beck's, their account-books showed that *the altered instrument had been delivered on October 25th*, 1850. On the same day that it was sent home, I recollect that I went down to Greenwich with Dr. Leeson

to try it, and it answered its purpose admirably; thus two persons were working out the same principle at the same moment (as has frequently happened before in the records of Science) quite independently of each other; and I think Dr. Leeson* can as fairly claim this form of Microscope for England as Professor J. L. Smith may for America.

The principle of introducing reflecting prisms into the construction of the Microscope was, I believe, first employed by Chevalier of Paris, who used a triangular prism in the body, over his lenses, these being attached at right angles to the body and pointed down to the stage; here, however, the prism was a more than useless intervention, the prism only being justified (on account of loss of a small portion of light) when the object-glass is to be placed *under* the object, as in cases where vapours would arise, and thus dim or attack lenses placed over them; this specially obtains when chemical solutions are to be examined, and where heat must be employed. If, however, Chevalier, by a modification of his arrangement, used, as I believe he did (though I have never seen his instrument), the lenses under the object, then THE PRINCIPLE is due to him; the advantageous modification of the angle at which the body is placed, and the resulting position of the stage, to Professor Smith and Dr. Leeson; the economical adaptation of Soleil's and other instruments, and the general improvement in the arrangement and adjustments to myself.

In the beginning of 1851 I sent a coloured drawing of the instrument as I required it modified, and as represented in fig. 3, to M. Nachet, who, however, from press of business, could not get it made for me as quickly as I wanted, and I afterwards got it executed in this country; Kobell's Stauroscope I have, of course, added since.

The instrument Professor Smith calls THE INVERTED MICROSCOPE, I, in its modified form and from its more general application to crystallological researches, call THE MINERALOGICAL MICROSCOPE, which I shall now proceed to describe.

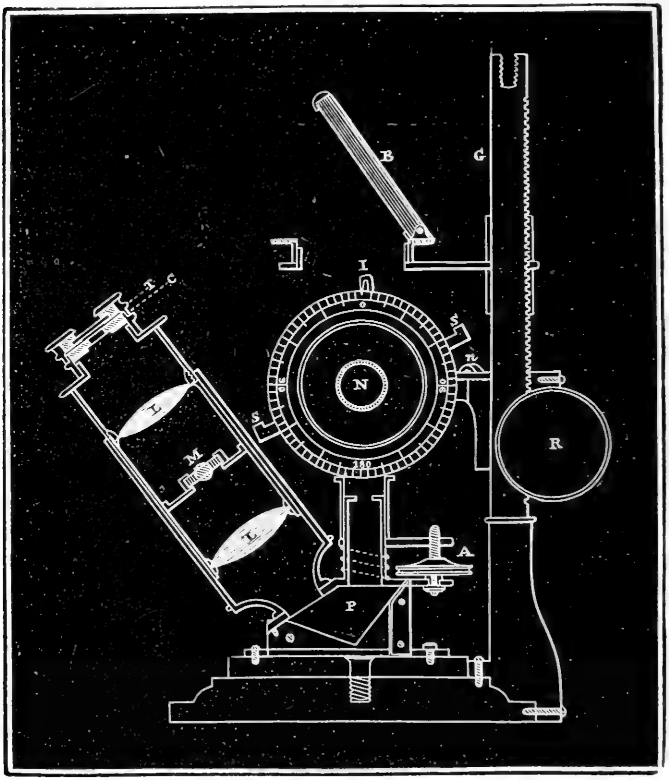
The instrument is shown in fig. 3, as arranged for ordinary structural observations, whilst in fig. 4 it is represented in section, arranged for the optical characters of mineral bodies.

The Base—on a central pivot, screwed into a solid circular base, rotates a plate that carries the body, prism-box P, object-glass and fine adjustment A; to the side of the base is firmly attached a square bar G, that carries the principal stage with

* Dr. Leeson has never described this, or laid any claim to the invention as yet.

its coarse rackwork adjustment R, and the secondary stage, on to which fits the diaphragm, polarizer, selenite plates, &c. A tube screws into the top of the bar G, on which slides the mirror. The object-glass and stages are centered, but the mirror has free motion round the supporting-rod.

Fig. 4.



The Body slides into a socket attached to the prism-box at the proper angle, so that its axis shall be perpendicular to the outer face of the prism P. Within the draw-tube there are fittings to receive glass tubes for examining with a Leeson's goniometer and minute-stop, the amount of rotation in liquids that exhibit Circular Polarization. If in place of the long body, a tube of iron, round which copper wire has been wound, be used, and the ends of the wires be connected with 12 or more cells of a Groves or Maynooth battery, the rotation of a polarized ray may be effected.

A shorter body for other optical examinations replaces the ordinary one; this is fitted with a Tourmaline T, a cell for a plate of calc spar C, [cut at right angles to the principal axis of the Rhombohedron or Hexagonal Prism,] when the instrument is to be used as a modification of Professor Kobell's Stauroscope for determining Crystal-Systems; and two lenses L L, with a Jackson's Micrometer M, at the point of their foci, when required for the determination of the optic axes on the principle of Soleil's Instrument.

The Prism P, is contained in a solid brass box, on the upper surface of which is screwed the tubes that carry the object-glass; and one side is removable to allow of the prism being readily taken out and cleaned.

The prism itself is six-sided, and has four polished faces with angles of such dimensions, that a ray of light reflected down the axis of the object-glass suffers two internal total reflections, the second being axial to the body of the Microscope. The angles and quality of the glass are points of the greatest importance in the construction of this instrument, as also are the proper adaptations of the object-glass and body to the line of reflection.

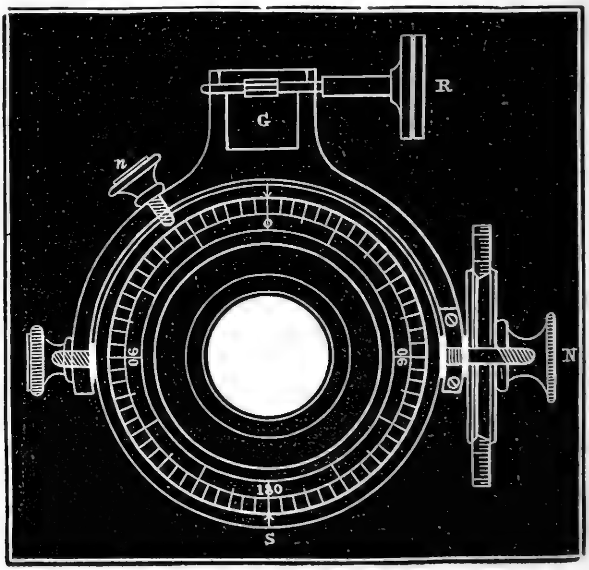
Angles.		J. L. Smith.
Upper obtuse	=	145°.
,, acute	=	55°.
Lower obtuse	=	107½°.
,, acute	=	52½°.

The Fine Adjustment consists of a tube screwed into the top of the prism-box at right angles to its surface; over this, tightly, but smoothly, slides another tube on which the object-glasses are screwed. This is kept up to its work by a spring of coiled wire, on which it rests; at right angles to its base an arm projects, through which the fine-wormed screw of the milled-head adjuster A works. The spindle of the adjuster A, rotates in a socket projecting from the prism-box.

The Stage differs materially in its construction from that of Professor Smith's or Nachet's, and allows a far wider scope for pursuing the physical examination of mineral bodies. A stout semi-circular arm works up and down the upright bar G, by means of a rack and pinion R. This supports a circular stage S, figs. 4 and 5; two axes at the circumference of the stage pass through the extremities of the arm; the stage being kept in a horizontal position by means of the nut *n*, which passes through the arm into the stage; the nuts, N, screwing on to the axes, clamp the stage firmly to the arm. The stage has a projecting ring, within which a graduated plate rotates when certain optical examinations have to be made, but which

is ordinarily fitted with a plain metal plate that rises flush with the top of the axes of the stage, or this may be replaced with another plate, which rests on three screws, and has an arm projecting from one side, by which heat may be communicated to the centre of the stage, when a spirit-lamp is placed under it; the three points of support not allowing the heat to be communicated to the other metal work. These three plates have apertures in their centres, with screw rings, so that they may be fitted with circles of thin glass, when liquids are used. If a movement is required beyond that afforded by the object slides having free play in all directions, a circular plate of metal or glass, about $\frac{3}{4}$ inch less in diameter than the bottom plate of the stage, with an inch aperture in the centre, may be used as suggested by Professor Smith, motion being imparted by the operator's fingers, or a Tilley's, or any other form of mechanical movement may be fitted within the ring of the stage. Of course, in this instrument the object has to be placed with the thin cover downwards.

Fig. 5.



By removing the nut N, the stage has free movement on its axes, and may be inclined to any angle, as is shown in fig. 4, S. S. One axe is longer than the other, and is so arranged that the graduated circle before mentioned may rotate on it, and be clamped, when desired, by the nut N. An index-

point I, fig. 4, rises from the stage arm as the starting-point for the readings. Thus, in measuring the optic axes of a crystal, the stage is inclined till one optic axe is properly cut by the micrometic lines M, in the short body; the graduated circle rotated till zero stands opposite the index-point I, and is there clamped; the stage is again inclined till the second axe cuts the micrometic lines, and as the graduated circle has passed on with the stage, the readings are taken from the fixed index-point I. This circle is graduated from 1 to 180 on each half, so that the reading may be taken on whichever side the stage may be inclined. Its use as a Wollaston goniometer, and other operations for which this is adapted, will be given under the proper heads of these CONTRIBUTIONS. The graduated circle also fits over an eye-piece containing a double-image prism, and thus constitutes a Leeson's goniometer. The manipulation and details of construction will be given under the head of "Goniometry." It will thus be seen that one graduated circle economically does the work of three by this arrangement.

The Secondary Stage requires no special description, as the ordinary accessory instruments are mounted so as to slip on a ring that rises from its surface. I find a reflecting bundle of thin glass the best Polarizer for this form of Microscope; by removing the back and using the plain mirror, it may also be used as a Refracting Polarizer. An electro-magnet arranged so that its poles, which terminate in small sliding cones, may be brought into the field of view without intercepting much of the light reflected from the mirror, is mounted on a fitting, so that when required it slips on the square bar G, between the principal and secondary stage.

It will be readily seen that this form of microscope possesses great advantages for chemical and mineralogical investigations, as the stage is in a far better position for the eye to watch the manipulations than in the ordinary instruments; and the object-glass being under the object cannot be dimmed or attacked by the vapours arising from the liquids under examination. In fact, Professor Bailey uses hydro-fluoric acid to determine whether markings on a siliceous body are to be regarded as elevations or depressions, as those parts that are elevated will be last seen under the dissolving action of the acid. Professor Riddell, in a note to Professor Smith, states, that after twelve months' trial he will not willingly return to the habitual use of any known form of microscope, "especially with high powers."

Moreover, as the plate that carries the body and object-glass rotates on the base, when the parts are properly centred, this may be used as a Demonstrating Microscope, as the body can

be rotated to two persons on each side of the demonstrator after he has arranged the object, and thus be examined by five persons in succession. This has the advantage of economy over Nachet's three and four bodied microscopes (see vol. ii., page 72), even if some of its other points are not attained.

Re-agent Bottles.—In vol. ii., page 58, of this Journal, my friend Dr. Beale described and figured a Re-agent Drop-bottle used by him, and an improvement on its form by myself. Finding that many persons meet with a difficulty in filling them by the plan there recommended, though it is a very simple operation, and moreover, that certain re-agents are decomposed when they enter the heated bottle, I have again improved its construction, which will be readily understood by fig. 6. Instead of drawing out the neck of the bottle to a capillary-tube, a piece of thermometer-tube is drawn out to a fine point, and is then ground into the neck of the bottle like a stopper; on the outside of the neck a glass cap is ground in the same way as in a spirit-lamp. When the bottle has to be filled, the drop-tube stopper is removed, and firmly replaced after the bottle is about two-thirds full, the warmth of the hand affecting the contained air that rises to the end of the bottle when the drop-tube is pointed downwards on a slide, forces the liquor through the thermometer-tube stopper drop by drop; and this is more satisfactorily effected, as the bore is of one diameter along its whole length, instead of being an elongated cone as in the old form. There should be a sufficient quantity of these in a proper case; such, with the other instruments here described, may be obtained of Messrs. Murray and Heath, opticians, of 43 Piccadilly. Watch-glasses, excavated and plain slides, stirrers, a Smee's battery for electro-chemical decompositions, and a Groves' battery for examining the effects of electro-magnetic currents on crystallization, &c., will complete the micro-mineralogical laboratory, which may equal, if not rival, Wollaston's laboratory that was contained in a tea-tray.

Fig. 6.

TRANSLATIONS.

LEUCKART *on the* MICROPYLE *and* MINUTE STRUCTURE *of the* EGG-SHELL *in* INSECTS. (Müller's Archiv., 1855, p. 244.)

THE Author, from observations made upon the ova of 180 insects belonging to the most various groups, is induced to come to the following conclusions. As regards more especially the existence of a micropyle, he conceives that no doubt can be entertained with respect to the following points:

1. That this apparatus is characteristic of all insect ova;
2. That it consists sometimes of a simple, sometimes of a compound orifice, which passes through the tunics of the *ovum*, and serves
3. For the admission of the spermatic filaments.

The last-noticed fact, it is true, has been demonstrated in but a small number of species—not more than about a dozen—but it may, nevertheless, perhaps be regarded as quite as certain as the others. For the doctrine of impregnation, however, this latter proof is of the highest importance, as by it alone has the question respecting the micropyle of animal ova received its physiological solution. Hitherto it might always be doubted—as in fact it always has been—whether the openings and canals which were some time since discovered to exist in the envelopes of the ovarian ova in various animals, and compared, as regards their external conditions, with the micropyle of the vegetable ovum, also really possessed the physiological import of that micropyle. The researches and statements of Keber cannot be regarded as having solved this question, since the spermatic corpuscle, whose penetration and metamorphoses were so laboriously described by that observer, is, as is well known, anything but a spermatic corpuscle at all, being only a thickening of the vitelline membrane at the base of the micropyle process, and to be found unaltered even after the escape of the embryo (vide Bischoff, 'Widerlegung,' and Hessling, 'Zeitsch. für wissenschaft. Zool.' vol. v. p. 392). The preceding observations, therefore (by Leuckart, in Müll. 'Archiv.' 1855), together with those of Meissner, of which they are quite independent, are the first, and, up to the present time, the only ones demonstrating the penetration of the spermatic filaments

through a micropyle in the animal ovum. Meissner's researches noticed above, however, can, Leuckart says, be taken into account in part, so far only as they apply to the insect-ovum. His statements respecting the ovum of *Ascaris* and its micropyle, Leuckart is unable, as concerns the present question, to regard as decisive, as he always found it impossible to convince himself, in general, of the existence of a vitelline membrane (Eihülle), nor, consequently, of a micropyle, at the proper stage of development of those ova. Had it even been proved that the conical discs regarded by Meissner as the spermatic corpuscles, and which he states penetrate into the vitellus through a micropyle, were really the fertilizing elements, even in this case he is only prepared to admit this much—that Meissner had shown in the Ascarides the penetration of the spermatic corpuscles into the, as yet, *membraneless* vitelline mass.

Previously to the observations of Meissner and Leuckart, the known number of animals whose ova are furnished with a micropyle apparatus was very small. Among these could be reckoned with certainty only the *Holothuriæ* (Müller, Leuckart, and Leydig) and *Ophiothrix fragilis* among the Echinoderms (J. Müller), *Sternaspis thalassimoides* among the Worms (J. Müller), *Unio*, *Anodonta* (Leuckart, Keber, Bischoff, Hessling) and *Venus decussata* (Leydig) among the Bivalves. All these animals have a simple micropyle, which, according to Leuckart's observations on the *Naiadæ* (Wagner's 'Handw. d. Phys.' Art. Zeugung, p. 801) and *Holothuriæ* (Bischoff's 'Widerlegung,' p. 39), and which have since, in all essential points, been confirmed on various sides, always appears to be developed as a kind of *stigma*.

It might, consequently, almost have been concluded that the micropyle, in general, existed only in those ova which, at an earlier period of development, had been in continuous connexion with the wall of the glandular follicle. The discovery of the micropyle of the insect-ovum shows how hasty such a conclusion would have been. We find a micropyle in ova which are at all times free in their glandular follicles; it is clear, also, that this opening is formed in some other way than by the dissolution of a previous connexion—that it may arise in consequence of resorption. To this may be added, that the micropyle apparatus of the insect-ova, according to my researches, presents the most remarkable diversities in form and construction—such, in fact, as could hardly have been previously imagined. Besides ova with a simple micropyle, we are now acquainted with numerous instances in which they are furnished with compound, and

even with many such openings—with micropyles extending over larger and smaller portions of the whole vitelline membrane.

These latter instances render it very probable that the peculiar system of orifices and canals which, according to the observations of J. Müller ('Monatsb. der Berlin. Akad.' 1854, p. 164) and Remak (Müller, 'Arch.' 1854, p. 252), pervades the chorion of our indigenous osseous fishes, also belongs to the category of micropyle apparatus, and is subservient to the act of impregnation. It is true that this explanation of the import of these passages can only be satisfactorily established by means of the microscope; but this will perhaps remain a problem of difficult solution, as it can scarcely be supposed that the spermatic filaments penetrate through the solid chorion and make no use of the openings. It is far more doubtful with respect to the radiating streaks in the *zona pellucida* of the mammalian *ovum*, which are compared by Remak with these orifices in the fish's egg. It does not even appear that these markings can properly be esteemed as the optical expression of canals, seeing that neither *lumina* nor orifices can be perceived in them. This much, however, seems to have been made out, that the markings depend upon a definite structural condition; it must even be allowed that the same conditions of structure may possibly indicate the way followed by the spermatic filaments in their passage into the ovum, and by which they penetrate the *zona pellucida*. Even as canals, these passages would still require dilatation in order to allow of the transit of the spermatic filaments, which are found in the interior with their heads and tails. In adverting to these micropyle-like markings, J. Müller takes occasion to notice the radiating lines of the chorion in the ova of *Tænia*. Leuckart has examined this in various species (*T. serrata*, *T. cœnurus*, &c.), and, from the optical conditions presented, is satisfied that the markings depend upon closely-placed perpendicular canals (1-2000‴). But, whether these canals penetrate the chorion completely, he leaves undecided. And it must, of course, remain equally doubtful whether they fulfil the function of a micropyle. At the same time, he says that he does not believe such to be their nature; in the first place, because these canals in other cestoid worms (*Ligula*, *Tetrarhynchus*), as well as in *Tænia cucumerina*, &c., are wanting, and also, for the reason that since, according to the anatomical conformation of the sexual organs in these animals, impregnation takes place before the formation of the *chorion*, any introduction by means of a micropyle can scarcely be required.

In general, he is of opinion that we are by no means justified in assuming the existence of a micropyle-apparatus universally in the animal ovum. That for the purpose of impregnation, it is in all cases necessary that the spermatic filaments should come into immediate contact with the *vitellus*, can no longer admit of doubt, from the result of recent experiments, and particularly from the researches of Newport (on the Frog's egg), of Bischoff and himself (on the Frog's and mammalian ovum), of Meissner (on the mammalian ovum), and of Lacaze Duthiers (on that of *Dentalium*), leaving out of the question the observations on the eggs of Insects—but this contact may probably be brought about in different animals by different modes. In the same way that the existence of an operculum, of valves, and similar provisions for the liberation of the embryo from the coats of the ovum, is limited only to certain species of animals; that is to say, is governed by certain external conditions, although the embryos, without exception, are liberated: so, also, is it probable that the existence of a micropyle for the admission of the spermatic filaments is confined within certain bounds. We are already in a position partly to determine, *à priori*, the conditions under which the presence of a micropyle in the animal ovum is rendered a physiological necessity. This will be the case especially in those instances in which the ova are very early, and before they come in contact with the spermatic fluid, surrounded with a firm and resistant envelope, the penetration of which would resist all the boring powers of the spermatic filaments. This would happen more especially with ova furnished with a chorion (that is to say, with a second, usually very firm envelope, formed in the ovary), in which we may predicate the existence of a micropyle. To this kind of ova belong, also, nearly all those cases in which we have hitherto found micropyle-organs—the ova of Insects and of osseous Fishes—those of the *Holothuriæ*, and also of the Bivalves.

It can scarcely, perhaps, be assumed that our observations respecting the occurrence of the micropyle in the *ova* of animals are at present conclusive. We shall undoubtedly meet with such a provision in numerous other animal forms. In most cases, we should certainly not place too high a value upon the negative results of earlier observations. Personal experience will show how easy it is to overlook an apparatus of the kind, especially when it is confined to a limited spot, and is otherwise indistinctly indicated; and it will be seen that such a denial of its existence is unjustifiable. As regards himself, Leuckart would remark that, notwithstanding

some experience in the detection of this apparatus, he has, nevertheless, in many cases been compelled to make prolonged and often-repeated examination, and to devote the closest attention to the subject, before satisfying himself with respect to its existence and conformation. Had he not entertained, *à priori*, the firmest conviction of its existence, it would in many Insects certainly have escaped him.

On the other hand, however, he says we must not expect that the existence of a chorion is in all cases associated with a micropyle. The chorion may possibly not be formed until after the fertilizing contact with the spermatic filaments has taken place, as in the Turbellariæ, Trematoda, and probably also in the Cestoidea, in which, to judge merely from the anatomical conformation of the sexual organs, the spermatic *filaments* are enclosed at the same time with the *vitellus* and the germinal vesicle, in a hard chorion-like capsule. According to Meissner, the ovum of *Gammarus* has a micropyle only in the vitelline membrane, over which the chorion is continued; in this case, impregnation, without doubt, takes place also before the deposition of the chorion.

We have thus sought to refer the physiological necessity of a micropyle at once to the physical condition of the egg-membranes which are formed before impregnation has taken place. But, at the same time, it can by no means be said that such a provision is exclusively confined to ova furnished with firm membranes. There remain numerous other conditions which, even in the case of a soft and delicate covering to the *ovum* (Meissner expressly remarks of the vitelline membrane in *Gammarus*, which has a micropyle, that it is "excessively delicate"), render the existence of a micropyle, if not absolutely necessary, still advantageous. But in any case, the occurrence of the micropyle under these circumstances will, of course, be far more limited than in *ova* having a hard and less penetrable covering.

Thus there may be said to be three distinct modes in which impregnation, that is to say, the contact of the spermatic filaments with the vitellus, is brought about:—

1. The entrance of the spermatic filaments, with penetration of the egg-covering;
2. Penetration through micropyles; and
3. Penetration into the vitelline mass before the deposition of the membranes of the *ovum*.

To which may be added a fourth mode of contact, lately pointed out, more particularly by Meissner:—

4. Contact through premature dissolution of the vitelline membrane, as takes place, according to Meissner, for instance, in the Earthworm. The Gasteropoda, also, in which a similar condition has been long known (vide Leydig. 'Zeitch. für wissenschaft. Zool. Bd.' ii. p. 127), might probably be here included, as well, perhaps, as the Hirudineæ and others of the Invertebrata.

What becomes of the spermatic filaments after they have penetrated, and what particular part they may play in the changes which we know immediately succeed the so-termed impregnation, we are at present scarcely in a condition to surmise. This much only is known with certainty—that the spermatic filaments, some of which enter the *vitellus*, whilst some remain in immediate contiguity with it, between the vitellus and its membrane, gradually dissolve (according to Leuckart's observations in *Melophagus* and *Ephemera*, far more quickly than the filaments which remain external). Whether this dissolution take place in consequence of a kind of fatty metamorphosis, as Meissner states, or of a simple disintegration and liquefaction, Leuckart is unwilling to determine. It is sufficient to know that the filaments which have entered are dissolved. But what farther becomes of the remains of these fertilizing elements is at present wholly unknown. It is highly probable that the substance of the spermatic corpuscles, after their dissolution, becomes mixed with the *vitellus*, but whether in a fluid or a molecular form we know not—not knowing, even, whether this commixture be deferred until impregnation is completed, and is consequently, to a certain extent, only adventitious and incidental, or whether it afford an impulse of some kind essential to the process of impregnation and development. Still less, therefore, are we in a condition to determine whether, in the latter case, the remains, whatever they may be, of the spermatic filaments directly participate in any way in the formation of the embryonic cells, or, indeed, in the construction of the embryo. The demonstration of an immediate contact between the spermatic filaments and the vitellus is undoubtedly an important and interesting fact in the history of impregnation, but one which, it is to be feared, will not soon be brought within the compass of our sensual perceptions.

REVIEWS.

Transactions of the Pathological Society, Vol. VI.

The volume of the Transactions of the Pathological Society for the present year has been punctually delivered to its members. It possesses the high qualities which we have had occasion to praise in its predecessors, and, to us, it has the additional interest in being another example of the increased appreciation of the microscope in the prosecution of pathological investigations.

In the present volume the great majority of the illustrations are of pathological histology, and there is scarcely a single specimen referred to in which the microscopical appearances are not recorded; this work, therefore, falls naturally enough within our limits to review; and while, as we have already said, there is much to admire, and much to praise, in these published details of a year's accumulated labours of the Pathological Society, we think, in this Journal, we may very properly point out and criticise those shortcomings and those errors which here and there exist, and which in one or two instances form unsightly blots on the pages of a beautiful volume. We must, however, assure those whose productions are unfavourably noticed, that they are criticised in no unfriendly spirit, but rather to enforce a more scrupulous caution for the future; and, we believe, we may safely add, that subsequent volumes of the Pathological Transactions will not suffer by the adoption of our suggestions.

Among the list of contributors to the present volume we find a goodly array of names, principally of young, earnest, working men; and among the specimens exhibited are many of rare interest.

Of the 161 original communications, and the 18 reports on specimens by referees, we will select a few of the more interesting; we cannot, however, help expressing our regret, that the reports of the referees bear so small a numerical proportion to the original communications; for we have always considered that the plan adopted by the Pathological Society, of referring all doubtful specimens and disputed points to the scrutiny of a committee of two or more gentlemen, who have paid particular attention to subjects similar to, or identical with that in dispute, has constituted one of its best characteristics, and has given peculiar weight and value to statements which have emanated from its members. In the present

volume we fear the officers of the Society have scarcely availed themselves sufficiently of this wholesome surveillance of referees.

Beginning with the diseases of the nervous system, with which the present volume of the Transactions of the Pathological Society commences, we observe an interesting account of neuromatous tumours on the posterior tibial nerve, by Dr. Van der Byl, the structure of which was investigated by Dr. Snow Beck, who comes to the following conclusions, based upon a careful microscopical scrutiny :—

"1. That neuroma originates in an individual fasciculus, and is confined to the fasciculus in which it commences.

"2. That the adjoining fasciculi become altered by the pressure of the tumour, but more especially by the constriction of the cellular tissue of the neurilemma.

"3. That these tumours originate in a deposit within the membrane surrounding the nervous tubules.

"4. That the individual tubules in the fasciculus become altered, from the pressure of the deposit which has taken place amongst them.

"5. That this deposit becomes organized, subsequently grows, and finally obliterates all appearance of the nervous structures amongst which it originates."

Among the "Diseases of the Organs of Circulation," we find an account, by Dr. Wilks, of a very curious disease of the heart, consisting of cysts adherent to the outer surface of the organ, and composed principally of a fibrous tissue, displaying great peculiarities of structure.

The walls of these cysts were composed of interlacing fibres, many of which hung by free extremities into the cavities of the cysts, and "to them are attached a number of earthy bodies, of a round form, semi-transparent, yellowish, very hard, and each of about the size of a pin's head." The fibres themselves "have a beaded, nodulated, or varicose form; that is, they consist of a slender stalk, which swells out at intervals into oval or rounded dilatations, and passing continuously through them, without much variation of outline, appears as a firm fibrous band." These oval nodes on the fibres have a central band passing through them, and appear like beads on a string. Some of these nodules overlap each other, others being widely separated; others again are faintly marked on their surface by two concentric rings.

Of the real nature of this specimen, Dr. Wilks does not venture to hazard an opinion. The structure is certainly very remarkable, and we do not remember that anything exactly similar has been recorded.

Another interesting communication relative to a morbid condition we have not previously described, also from the pen

of Dr. Wilks, consists of an account of fatty degeneration of the malpighian bodies of the kidney, all the other structures of the gland, *including the tubes*, being free from that change. The illustrations of this Paper, as well as the previous one, are from original drawings by Dr. Wilks, and are very beautiful; but, in the one we are now considering, this usually accurate observer has made a somewhat singular mistake in the magnifying powers he has represented. The three figures given in the Plate in question are said to represent different portions of the gland, magnified respectively 6, 40, and 160 diameters. Now, between these numbers, there is a certain proportion; and we should expect to find the same proportion in the structural elements, as represented in the several figures; but here we are disappointed. The first figure is said to represent "a small portion of the kidney, as viewed with a simple lens. Magnified 6 diameters." And this, from the size of the opaque white malpighian bodies, is no doubt pretty correct. The second figure of the same, "magnified 40 diameters," is also probably correct; and the two have, as they ought, about the proportion of 1 to 7. But in the third figure, "magnified 160 diameters," Dr. Wilks seems to have lost sight of proportion altogether, for he has represented the malpighian bodies in this figure, not four times the diameter of the second, as we should have supposed, ($40 \times 4 = 160$,) but eight times. Supposing, however, that the two former figures be correct, which we believe them to be, the third figure should be defined as magnified 320 diameters.

Among the most interesting histological specimens in this volume, are some examples of osteoids—in and among fibrous tissues of various organs. Dr. Kirk gives two interesting examples of formations of bone in eyes damaged and rendered useless by long previous disease; and the specimens have been fairly described and illustrated. There are some points, however, to which we must take exception. In the first place, the description of the first figure, (Pl. XIII., fig. 1,) "showing the earthy matter exposited in the form of granules in a fibrous stroma," involves an idea which we believe is not a true expression of the calcification-process. We would suggest, as more probable, that these little spherules may be of the same nature as those described by Dr. Hyde Salter in the fifth volume of the Society's Transactions, as occurring in an osteoid in the pleura, consisting of minute isolated globules, in which the earthy matter has impregnated the animal, like the calcification-globules of dentine.

In fig. 1 *a*, we certainly have failed to see the "crystalline" appearance described by Dr. Kirk; and we notice, moreover,

between this figure and the preceding one a total disproportion of measurements—the latter figure being full ten times less than the former, instead of five, according to the magnifying powers stated. The same disproportion, in figures 2 and 3, exists between the lacunæ magnified 250 diameters, and those stated to be enlarged 50 times; the former are full ten times larger than the latter. But the most remarkable examples of confused and erroneous microscopical measurements are to be found in observations by Drs. Jenner and Hellier, on some osteoids from the lungs and omentum of a patient who died from malignant disease of the femur after fracture. The history of the case, which is very interesting indeed in a general pathological sense, we shall not follow, as it is foreign to our present object. On the description given of the structure of the specimens, however, we have unfortunately too much reason to comment; we ought rather to say, *of the total absence of description;* for even under the head of "More minute examination of the morbid growths," though a subsequent paragraph is commenced—"The growths in the lungs," Plate XV., figs. 1, 3, 4,—which figures, by the way, are intended to illustrate bone-lacunæ—no account whatever is given of anything osteoid, and no description certainly of the structures, the figures of which are referred to: and, indeed, we should be altogether in uncertainty about the nature of these very curious and interesting specimens, were it not for the few words given in explanation of the plates; and these, too, are insufficient. The Plate in question contains four figures, not very artistic, certainly, but conveying a general appearance of bone structures, as seen with high and low powers. Figures 1 and 3 exhibit sections of a sort of cancellated bone, not well expressed in the drawing; magnified, as we should have supposed, some 60 or 70 diameters; but to our astonishment we discovered that, according to Dr. Hellier, they are magnified no less than two hundred diameters. We have seen many specimens of bone from various sources; but lacunæ of such minute dimensions we have never previously observed. Referring to figure 4 in the same Plate, we find some enormous isolated lacunæ, taken from the previous specimen; and as they are in diameter some ten or fifteen times larger than those in that specimen, we expected to find that they had been magnified some two or three thousand diameters. Imagine, therefore, our surprise at discovering that they had been enlarged only 400 diameters, according to the statement of Dr. Hellier! There is yet another figure in this Plate, fig. 2, which we confess we do not quite understand; and the "bone with large lacunæ," said to be

represented at letter *c*, we certainly have not been so fortunate as to discover. Appended to the foregoing Paper, we find a report, by Dr. Jenner, on the Microscopical Appearances of the Osteoid Deposits in the Lungs, but were it not for the heading, we might have some difficulty in guessing to what the report in question referred, as there is nothing in it bearing upon the subject of osteoid structures.

We must here close our notice of individual papers, which has already occupied a larger space than we originally intended. At the same time, it is fair to state that criticisms, such as we have made upon those above noticed, are not applicable to others. Indeed, taken as a whole, the sixth volume of the Transactions of the Pathological Society is probably the best and most valuable that has been issued since its commencement. Most of the communications are of much interest; many are decidedly original, and to the majority we can accord our unqualified approbation. We would now venture to suggest to the future contributors of the Pathological Society, a few considerations which have occurred to us.

In the first place, we would urge the propriety of carrying out the system of reports to a greater extent. As we have before said, it gives *safety*, and consequently *weight*, to published statements; and care should always be taken to select the *riaht referee for the right specimen*, about which, we should presume, there cannot be much difficulty. Again, the method of illustrating papers requires careful supervision. Illustrations of pathological histology in one publication should, we think, *as far as possible*, be rendered upon a fixed scale—say by magnifying powers of hundreds or parts of hundreds—50, 100, 200, 400 diameters, and so on. If such a method were adopted, it would give an intelligible relationship between different Plates and figures, and a unity, not less agreeable than useful, to the entire volume. One more suggestion: we would recommend gentlemen who cannot draw from the microscope, not to attempt it. Few things are more difficult than to render well upon paper, objects that are seen through the microscope; and it would be far better for observers to place their specimens at once in the hands of Mr. Tuffen West, who illustrates the Pathological Transactions, than to furnish him only with ill-executed and incorrect representations of their own. Mr. Tuffen West combines in himself the accomplishments of a good microscopist, and an artist of the nicest and most accurate touch; and by his single exertions, in this Journal and in the Transactions of the Pathological Society, he has created a new era in the illustrations of normal and abnormal histology.

The members of the Pathological Society are under peculiar obligation to Dr. Quain, their accomplished secretary; who, unassisted and alone, undertakes all the labour and responsibility of the annual volume, and presents it to them with an exact punctuality and completeness that do infinite credit to the Editor.

RUSTIC ADORNMENTS FOR HOMES OF TASTE. By SHIRLEY HIBBERD. London. Groombridge.

ALTHOUGH this work does not contain any microscopical matter that we can criticise, we can, nevertheless, recommend it to our microscopical friends, as containing a large amount of information about things in which the great majority of them will be interested. No microscopist should be without his aquavivarium, sea and fresh water, to enable him to carry on observations on the structure and habits of the creatures whose existence depends on water. A Wardian case, too, in which to grow ferns and other kinds of plants, will be necessary to those who are investigating vegetable physiology. Even the most learned in the construction of these things will be glad of additional hints, and we can promise them many useful remarks, not only on Aquariums and Ward's cases, but on Aviaries, Apiaries, Rockeries, Ferneries, and other things in this volume of Mr. Hibberd's.

THE MICROSCOPE. By DIONYSIUS LARDNER, D.C.L. London. Walton and Maberly.

THIS book is a republication of an article on the microscope in the Museum of Science and Art, and contains a vast quantity of matter, for the small price at which it is published. As far as the structure of the microscope goes, the descriptions and illustrations are accurate enough, but in the department devoted to the use of the microscope, it is very much inferior to most recent publications on this subject. The drawings of microscopic objects are defective, and sometimes inaccurate, a necessary consequence of their being selected from antiquated objects. Dr. Lardner, however well acquainted with the optical principles involved in the structure of the microscope, has certainly not kept up with modern discoveries made by its aid. We cannot but regret that so good an opportunity of getting out a cheap book on the microscope should have been lost for the want of competent assistance in that part of the work devoted to the practical applications of this instrument.

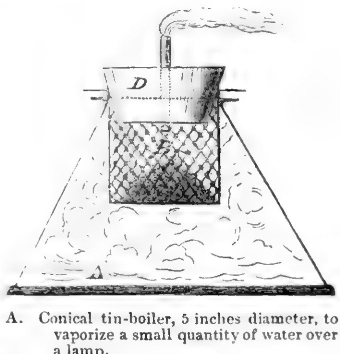
NOTES AND CORRESPONDENCE.

Microscopic Hints from Australia.—The Editors have received a copy of the 'Transactions of the Victorian Institute,' in which is a paper on 'Microscopic Investigation,' by Mr. W. S. Gibbons. From this paper they give an extract, and also add some illustrations, which have been forwarded to Mr. Jabez Hogg by the Author, for the purpose of explaining some of the apparatus he has successfully employed.

"Some years since I made some experiments in the use of the air-pump in making microscopic preparations, believing that it had not then attracted the attention of operators. Since that time, I found in a recent work an account of some uses that had been made of that instrument, but that which I found most advantageous was not mentioned, and appeared to have escaped the experimenter; while that most dwelt upon in the work in question is one that I abandoned as unavailing, nor have I seen occasion to change the opinion. The operator quoted immerses the objects in balsam, and then places them on a dry hot-bath under the receiver of an air-pump; the air is supposed to be extracted by this process from the minute pores or cells, and its place supplied by the balsam. I found, however, that in the majority of cases the viscidity of the balsam retains the bubbles of air even when they escape from the object, and that many of them return to their original positions on the restoration of atmospheric pressure. The plan I recommend as preferable, is to immerse the object in a bath of turpentine, and exhaust it before applying the balsam. The limpidity of the turpentine allows the free escape of air, and when the object is removed from the bath to be mounted, the balsam then blends with the turpentine, and follows it into minute cavities whither it could not alone have penetrated.

Fig. 2.

Steam Bath.



A. Conical tin-boiler, 5 inches diameter, to vaporize a small quantity of water over a lamp.
B. C. D. Cage of perforated metal to hold the objects C. It fits tightly at the collar D, and is stopped by earth with a small escape-pipe, so that the steam must pass round the object.

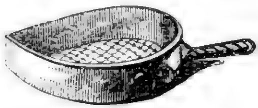
"Before quitting the subject of mounting, I may mention that I have found the common balsam of copaiba a useful medium in which to preserve objects of a delicate character, which it is not desired to mount immediately. I have used it cold, and have mounted the objects in it temporarily between two plates of glass; and have transmitted them by post and otherwise to distant parts of the country in perfect safety; objects so prepared may at once be mounted in Canada balsam without further preparation. The advantage derived from the use of copaiba is that it is not so viscid, and does not dry so rapidly as the other balsam, while its refracting properties are so little inferior that no detriment results from its use.

"The next point on which I have to make an observation that I believe to be original, is the mode of killing insects and other small animals. A paper recently read to the British Association mentions that cyanide of potassium has been employed for this purpose. I have had occasion to make some rather large quantities of this salt for other processes, and contemplated the employment of it as a means of destruction, for which its active poisonous property eventually fits it, but I was so well satisfied with other plans, that I have not yet tried it. I find that immersion in turpentine kills small insects almost instantaneously, and has the great advantage of making them protrude their probosces, lancets, and other organs—a very desirable effect; they are also more readily saturated and rendered diaphanous than after they have been allowed to harden. If it is intended to dissect the internal organs this plan will not do, and Swammerdam's plan of suffocating the animals in spirits will be found almost as rapid, and much more suitable. But the agent I most incline to in cases when turpentine is inadmissible, both on the ground of humanity, as causing speedy death, and for its preservative quality, which renders it suitable for the cabinet, is creosote. If the mouth and spiracles be touched with a pencil dipped in it, the creatures most tenacious of life soon yield to its influence. The use of spirit to suffocate the animal, and the exhibition of creosote to its mouth, &c., both present the advantage of hardening the viscera, which is very desirable, as it tends materially to assist the process of dissection—at least so long as the albuminous portions are not so much coagulated as to make the delicate organs cling together. There is risk, however, that cyanide of potassium would corrode delicate organisms, and thus be productive of mischief. Small soft-bodied animals are, by soaking in spirit, rendered less liable to injury in the process of compression.

"For the purpose of collecting aquatic animalcules, I use, in preference to any kind of net, stout tin hoops, about four inches

diameter and one and a half deep, nested for stowage. Muslin of different degrees of fineness is strained over one opening of the hoop, and a screw is attached by its head to the rim. The net is thus portable, and is screwed into a hole in the end of a walking-stick, or what is better a fishing-rod. I find that for most purposes the fabric called bobbinet answers very well, and catches creatures much smaller than its own meshes, while the free escape of water through the openings prevents their being washed out, as they frequently are in withdrawing the net from the surface. If the stick have a spike at the other end it may be stuck in the ground, and those animals that are visible to the naked eye leisurely picked out, with a small thin spoon or palette-knife, and transferred to bottles, care being taken that the more voracious ones be separated from their prey; while the thick residuum, containing infusoria, &c., may be ladled up or strained off into its appropriate vessel. On arriving home the contents of the bottles are poured into one of the finer nets, which is placed in a saucer of water. The drafting net is then lifted up out of the water, and a final classification may be made. To catch individual creatures that are too large for a fishing-tube, a small spoon-net, made of slips of thin metal, bent into the form of a spoon, with a large hole punched out of the bowl, and muslin cemented to the rim, will be found convenient. This form of net is free from the inconvenience of loose parts of material, in which choice specimens may be confused and lost.

Fig. 3.



Animalcule Net.

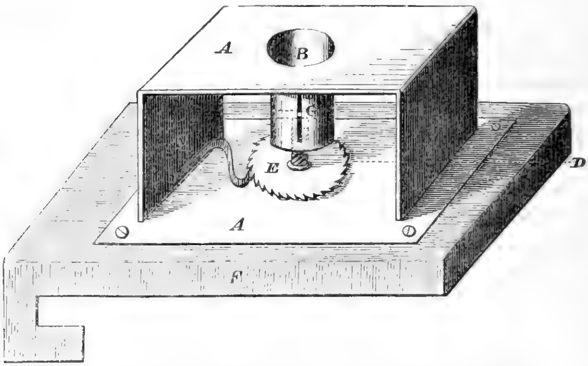
"Before concluding this paper, I may mention a very useful cement, for fine work, which was communicated to me by my friend Mr. Capewell, of Ballan. Canada balsam is heated and evaporated to dryness, and the residual resin dissolved in ether. This cement dries as rapidly as collodion, is perfectly limpid, and does not coagulate.

"I hope soon to submit to the Institute a section-cutting machine, which I am constructing on a plan different to any I have yet met with, and presenting, as I fancy, some conveniences. I have here some sections cut with it in its present state, but it is not yet mounted."

Through the kindness of Mr. Jabez Hogg the editors are enabled to present a drawing of this machine.

Fig. 1.

The Cutting Machine.



A A, consists of a stout brass frame, having an opening in the top plate.
B. Orifice of a tube half an inch diameter and one and a half long.
C. Loose piston working freely in the tube, and steadied by the slot in the side.
D, is a female screw, to which motion is given by the toothed wheel.
E. The teeth, which answer the triple purpose of thumb-milling, ratchet-stop, and graduation.
F. Block of wood, with rabbet to hold on the edge of a table. This machine is self-regulating, and may be worked as rapidly as the skill of the operator will allow. It admits also of very fine graduation.

New method of disintegrating Masses of Fossil Diatomaceæ.—Many masses of fossil Diatomaceæ are so strongly coherent, that they cannot be diffused in water, (for the purpose of mounting in balsam,) without a degree of mechanical violence which reduces to fragments many of the most beautiful and interesting forms. This is particularly the case with some specimens from the "infusorial deposits" of California. Some of these I endeavoured to break up, by boiling in water and in acids, and also by repeated freezing and thawing when moistened, but without good results in either case. At last it occurred to me that the adherence might be due to a slight portion of a siliceous cement which the cautious use of an alkaline solution might remove without destroying any but the most minute shells of the Diatoms. As the case appeared a desperate one, a "heroic remedy" was applied, which was to boil small lumps of the diatomaceous mass in a strong solution of caustic potassa or soda. This proved to be perfectly efficacious, as the masses under this treatment rapidly split up along the planes of lamination, and then crumbled to mud, which being immediately poured into a large quantity of water ceased to be acted upon by the alkali, and gave when thoroughly washed, not only all the large shells of the Diatoms

in a state of unhoped for perfection, but also furnished abundance of the minute forms. Having obtained by this method highly satisfactory results from specimens from many localities, I can confidently recommend it as an addition to our modes of research.

The following directions will enable any one to apply the process. Put small lumps of the mass to be examined into a test tube, with enough of a solution of caustic potassa or soda to cover them; then boil over a spirit lamp for a few seconds, or a few minutes, as the case may require. If the solution is sufficiently strong, the masses will rapidly crumble to mud, which must be poured *at once* into a large quantity of water, which after subsidence is removed by decantation. If the mass resists the action of the alkaline liquor a still stronger solution should be tried, as while some specimens break up instantly in a weak solution of alkali, others require that it should be of the consistence of a dense syrup. The mud also should be poured off as fast as it forms, so as to remain as short a time as possible in the caustic ley.

The only specimens which I have found not to give good results by the method above given, are those from Tampa Bay, Florida, and the infusorial marls from Barbadoes. In the masses from Tampa the lapidification is so complete, that the alkali destroys the shells before the lumps break up; and in the case of the Barbadoes marls the cementing material is calcareous, and requires a dilute acid for its removal. In applying the above process one caution is necessary, which is to thoroughly wash the shells with *water*, and not with acids, as the latter will cause the deposit of a portion of the dissolved silica and materially injure the beauty of the specimens. When the washings are no longer alkaline, the specimens may then be thoroughly cleansed by acids or by the chlorate process described in the last number of this Journal. (Vol. xxi. p. 145.)—J. W. Bailey, *American Journal of Science and Arts, 2nd Series, Vol. XXI, May*, 1856.

On the Non-Existence of Polarizing Silica in the Organic Kingdoms.—It is now more than twenty years since Sir David Brewster announced the existence of polarizing or doubly-refractive silica in the cuticle of Equisetum, and in that of some of the grasses. In Lindley's 'Natural System of Botany,' the following account of Brewster's experiments is given:—"On subjecting a portion of the cuticle of *Equisetum hyemale* to the analysis of polarized light under a high magnifying power, Brewster detected a beautiful arrangement of the siliceous particles, which are distributed in two lines parallel to the axis of the stem and extending over the whole surface. * * *

Brewster also observed the remarkable fact that each particle has a regular axis of double refraction. In the straw and chaff of wheat, barley, oats and rye he noticed analogous phenomena." (Quoted by Lindley from Grevill. Fl. Edinens., 214.)

In Quekett's 'Treatise on the Microscope,' 3rd ed., p. 358, directions are given for preparing the siliceous cuticle of *Equisetum hyemale* for microscopic examination, by boiling in strong nitric acid, and it is added that "in balsam it forms a beautiful object for polarized light." Similar directions are given for preparing the silica in the chaff of wheat, oats, &c.

As these statements are contained in the last editions of each of the above-mentioned works, it is evident that no contradiction of the error involved in them has been pointed out; yet, notwithstanding the high authority on which they rest, the statements so far as the polarizing action of the silica is concerned are wholly erroneous. If the cuticle of the above-mentioned plants is completely deprived of its carbonaceous tissues, it will be found wholly devoid of action on polarized light, and any preparation of the cuticle which is found to affect polarized light will also be found to blacken when heated in concentrated sulphuric acid, and if then decarbonised by throwing into the hot acid solution a little chlorate of potassa, the residual silica shows no signs of action under the polariscope, either alone or with the selenite plate, although it still retains the forms of the cells, stomata, &c.

It is clear then that the error in the above statements has been caused by the imperfect removal of the dense carbonaceous tissues which are deposited beneath the silica. I have examined several species of *Equisetum*, and a large number of plants of the grass tribe which are most remarkable for their siliceous cuticles, but have found no trace of any action upon polarized light, when the carbonaceous matter was removed. But it is unnecessary to resort to artificial preparations to prove the correctness of my statements. Nature has made her own preparations, and deposited them by myriads beneath every peat bog, where may be found not only the siliceous shells of the Diatoms, and the spicules of the fresh-water sponges, but also a large number of the siliceous parts of the grasses, sedges, &c. Ehrenberg has shown, (Berlin Monthly Reports, May, 1848,) and I can confirm his statements, that the silica in these *Phytolitharia*, as well as in the *Diatomaceæ*, *Polycistineæ* and *Spongiolites* is not doubly refractive. He makes an exception in the case of the shell of *Arachnoidiscus*, but my own experiments prove that when properly cleaned this shell forms no exception. As I have shown above that the silica in the cuticle of the *Equisetum* and grasses, agrees with that in the lower tribes in characters, I think the conclu-

sion is warranted, that doubly refractive silica has no existence in the organic world.—J. W. BAILEY, *Ibid.*

On some Specimens of Deep Sea Bottom, from the Sea of Kamtschatka, collected by Lieut. Brooke, U. S. N.—The following is a copy of a letter from Professor Bailey to Lieut. Maury, of the National Observatory, Washington, D. C., dated West Point, New York, January 29th, 1856.

I have examined with much pleasure the highly interesting specimens collected by Lieut. Brooke, of the U. S. Navy, which you kindly sent me for microscopic analysis, and I will now briefly report to you the results of general interest which I have obtained, leaving the enumeration of the organic contents and the description of the new species for a more detailed account which I hope soon to publish.

The specimens examined by me were as follows:

No. 1. Sea bottom 2700 fathoms, lat. 56° 46′ N., long. 168° 18 E., brought up by Lieut. Brooke with Brooke's lead.

No. 2. Sea bottom 1700 fathoms, lat. 60° 15′ N., long. 170° 53′ E., brought up as above, July 26th, 1855.

No. 3. Sea bottom 900 fathoms, temperature (deep sea) 32 Saxton, lat. 60° 30′ N., long. 175° E.

A careful study of the above specimens gave the following results.

1st. All the specimens contain some mineral matter, which diminishes in proportion as the depth increases, and which consists of minute angular particles of quartz, hornblende, feldspar, and mica.

2nd. In the deepest soundings (No. 1. and No. 2.) there is least mineral matter, the organic contents (which are the same in all) predominating, while the reverse is true of No. 3.

3rd. All the specimens are *very rich* in the siliceous shells of the *Diatomaceæ*, which are in an admirable state of preservation,—frequently with the valves united and even retaining the remains of the soft parts.

4th. Among the Diatoms, the most conspicuous are the large and beautiful discs of several species of *Coscinodiscus*. There is also (besides many others) a large number of a new species of *Rhizosolenia*, a new *Syndendrium*, a curious species of *Chætoceros* with furcate horns, and a beautiful species of *Asteromphalus*, with from five to thirteen rays, which I propose to call *Asteromphalus Brookei*, in honour of Lieut. Brooke, to whose ingenious device for obtaining deep soundings, and to whose industry and zeal in using it, we are indebted for these and many other treasures of the deep.

5th. The specimens contain a considerable number of the siliceous spicules of sponges, and of the beautiful siliceous

shells of the *Polycistineæ*. Among the latter I have noticed *Cornutella clathrata*, Ehr., a form occurring frequently in the Atlantic soundings. I have also noticed in all the soundings (and shall hereafter describe and figure) several species of *Eucyrtidium*, *Halicalyptra*, *Perichlamidium*, *Stylodictya*, and many others.

6th. I have not been able to detect even a fragment of any of the calcareous shells of the *Polythalamia*. This is remarkable for the striking contrast it presents to the deep soundings of the Atlantic, which are chiefly made up of the calcareous forms. This difference cannot be due to temperature, as it is well known that *Polythalamia* are abundant in the Arctic seas.

7th. These deposits of microscopic organisms, in their richness, extent, and the high latitudes at which they occur, resemble those of the Antarctic regions, whose existence has been proved by Ehrenberg; and the occurrence of these northern soundings of *Asteromphalus* and *Chætoceros*, is another striking point of resemblance. These genera, however, are not exclusively polar forms, but, as I have recently determined, occur also in the Gulf of Mexico and along the Gulf Stream.

8th. The perfect condition of the organisms in these soundings, and the fact that some of them retain their soft portions, indicate that they were very recently in a living condition, but it does not follow that they were living when collected at such immense depths. As among them are forms which are known to live along the shores as parasites upon *Algæ*, &c., it is certain that a portion at least have been carried by oceanic currents, by drift ice, by animals which feed upon them, or by other agents, to their present position. It is hence probable that all were removed from shallower waters in which they once lived. These forms are so minute, and would float so far when buoyed up by gases evolved during decomposition, that there would be nothing surprising in finding them in any part of the ocean, even if they were not transported (as it is certain they sometimes are) by other agents.

9th. In conclusion, it is to be hoped that the example set by Lieut. Brooke will be followed by others, and that in all attempts to obtain deep soundings the effort will be made to bring up a portion of the bottom. The soundings from any part of the ocean are sure to yield something of interest to microscopic analysis, and it is as yet impossible to tell what important results may flow from this study.

The above is only a preliminary notice of the soundings referred to. I shall proceed without delay to describe and figure the highly interesting and novel forms which I have detected, and I hope soon to have them ready for publication. —J. W. Bailey, *American Journal of Science and Art*, 1856.

PROCEEDINGS OF SOCIETIES.

MICROSCOPICAL SOCIETY, *March* 26, 1856.

GEORGE SHADBOLT, Esq., President, in the chair.

W. Fuller, Esq., Harley-place, Bow-road; W. W. Armstead, Esq., 35 Belitha Villas, Barnsbury Park; G. J. Brownlow, Esq., Alfred-place, West, Thurloe-square; and E. O. Spooner, Eagle House Blandford, were balloted for, and duly elected Members of the Society.

The following Papers were read: " On the Post-tertiary Diatomaceous Sand of Glenshira," by Professor Gregory (see Transactions, vol. iv., p. 35).

Notes on some Fresh-water Confervoid Algæ, by Arthur Henfrey, Esq. (see Trans., vol. iv. p. 49).

" On the Illumination of Opaque Objects under the highest powers of the Microscope," by F. H. Wenham, Esq. (see Trans., vol. iv., p. 55).

April 30, 1856.

GEORGE SHADBOLT, Esq., President, in the chair.

The Hon. and Rev. S. G. Osborne, Blandford, Dorset; H. Druce, Esq., George-street, Chelsea; and Henry Pollock, Esq., George-street, Hanover-square, were balloted for, and duly elected Members of the Society.

The following Papers were read: " Discussion on an Object Compressor for preparing and mounting Objects," by F. Hislop, Esq.

" On defining the position and measuring the magnitude of Microscopic Objects," by R. J. Farrants, Esq.

Mr. Busk gave an account of Mr. Dobson's observations on Loap or Lerp, the cup-like covering of *Phyllidæ* found on the leaves of certain *Eucalypti*.

ZOOPHYTOLOGY.

1. *Polyzoa cheilostomata.*

Gen. 1. *Membranipora*, Blainville. ('Brit. Mus. Cat.,' p. 56.)

1. *M. hexagona*, Busk. Pl. XII., fig. 4.

Area of cell hexagonal, or sub-elliptical; surface smooth; septa smooth, even; mouth semilunar.

Flustra coriacea, E. Forbes; Johnston, 'Brit. Zooph.,' p. 348. Pl. LVI., fig. 8 (*non* 'Esper Pflanzth. Flust.,' Tab. vii., fig. 2; Busk, 'Brit. Mus. Cat.,' p. 57. Pl. LXXIII., fig. 4, 5).

Hab. Coast of Devon, *Miss Cutler;* Isle of Man, *E. Forbes;* Fowey harbour, *Peach;* Sana Island, *Hyndman.*

The species figured by Esper, under the name of *F. coriacea*, is clearly not the same as the one here represented, which seems to correspond with E. Forbes' description and Dr. Johnston's figure. Esper's figure corresponds more nearly with the *M. coriacea* of the Brit. Mus. Catalogue, which is also a British form. For the specimen from which the present figure was taken, I am indebted to Miss Cutler.

Gen. 2. *Lepralia*, Johnston.

1. *L. ringens*, n. sp. Busk. Pl. IX., figs. 3, 4, 5.

Cells ovate, with a circumscribed area in front; surface minutely punctured, scaly?; a vibraculum on the front or side of the cell; mouth expanded below the base of the moveable lip into a transverse, sub-crescentic fissure; 4 to 6 marginal spines.

Hab. Shetland, on stone, *Barlee.* (In the Newcastle Museum, presented by Dr. Edward Charlton.)

A curious form which, as Mr. Alder, to whom I am indebted for the drawings from which the figures are taken, remarks, "has very much the appearance of a *Membranipora*, filled in with calcareous matter similar to the rest of the cell. There is a strong raised rim in the same position as in [some] *Membraniporæ.* The mouth is very curious. There is a wide transverse aperture, edged with a horny substance, below what appears to be the true mouth covered with the horny operculum; but I cannot," he says, "make out whether or not there is any calcareous division between the two. In the freshest cells the surface, when highly magnified, has a beautiful scaly appearance, each scale being perforated (*vide* fig. 5). In the older cells the perforations only appear."

2. *L. fissa*, n. sp. Busk. Pl. IX., figs. 8, 9, 10.

Cells ovate, immersed, quincuncial, or disposed in parallel contiguous

rows; surface smooth. Mouth raised, deeply sinuated below, with two or three unequal teeth on either side; four superior, marginal spines. Ovicell globose, with a triangular vertical fissure in front. Avicularia of various sizes distributed irregularly over the polyzoary.

Hab. Guernsey, *J. Alder;* Coast of Devon, *Miss Cutler;* Exmouth, *Barlee.*

The foregoing *Lepralia* was long since brought under my notice by my esteemed friend, Mrs. Gatty, to whom zoophytologists are under many important obligations.

3. *L. lata*, n. sp. Busk. Pl. X., figs. 1, 2.

Cells broadly-ovate, immersed, quincuncial; surface punctate or pitted, more especially around the border. Mouth rounded above, contracted below the middle, with a straight lower lip; margin slightly thickened. Ovicell rounded.

Hab. Bay of Gibraltar, on Shell, *Dr. Landsborough.*

4. *L. unicornis*, Johnston. Pl. X., figs. 3, 4.

This is the same species as the one figured in Pl. LXXXI. of the 'Brit. Mus. Cat.,' where it is regarded as a variety of *L. spinifera*, but I now think erroneously; whether it differ, however, from Dr. Johnston's *L. ansata* is far more doubtful; I am inclined to think that *L. ansata* is nothing more than *L. unicornis*, with the two avicularia. It is sometimes without those appendages at all, sometimes has one, and very often two. The latter form seems to be identical with the *Cellepora Dunkeri* of Reuss ('Fossil. Polyp. d. Wiener tertiar. Beckens,' Pl. X., fig. 27).

5. *L. Peachii*, Johnston. (Brit. Mus. Cat., p. 77.) Pl. X., figs. 5, 6. (Var. *labiosa*).

This thick-lipped variety, as I suppose it to be, of *L. Peachii*, was collected by Mr. Alder in the Island of Guernsey; I have it also from Belfast Bay, collected in deep water by the late Mr. Thompson.

6. *L. pallasiana*, Moll. (Brit. Mus. Cat., p. 81.) Pl. XI., figs. 1—2. (Var. *armata.*)

Most of the cells having an avicularium immediately below the mouth in front; mandible rounded.

Hab. Tenby, *Busk.*

This *Lepralia* agrees so perfectly in all other respects with *L. pallasiana*, that it is impossible, I think, to separate them merely on account of the existence of the avicularium below the mouth.

7. *L. Landsborovii*, Johnston. (Brit. Mus. Cat., p. 66.) Pl. XI., fig. 3.

The species here figured, appears to correspond in most particulars with that described by Dr. Johnston under the above appellation, of which the only specimen with which I am ac-

quainted is in his collection in the British Museum. The present figure was taken from a specimen collected by Mr. Alder, in Guernsey or Jersey; it was on an oyster-shell.

8. *L. punctata*, Hassal. (Brit. Mus. Cat., p. 79.) Pl. XI., figs. 4, 5.

The form here figured seems to correspond with *L. punctata*, in its most perfect state; it was collected in Gibraltar Bay, growing on shell, by the late lamented Dr. Landsborough.

9. *L. californica*, n. sp. Busk. Pl. XI., figs. 6, 7.

Cells broadly-ovate, surface minutely punctured; a lunate pore in front, a little below the mouth; an avicularium on either side above. Mouth rounded above, lower lip straight, four superior marginal spines. Ovicell small, sub-immersed.

Hab. California, *Dr. Gould*.

The specimen of this well-marked species was furnished to me by the kindness of Dr. Philip Carpenter. In the older cells the front is so much raised, that the mouth and the lunate pore, with the surrounding part of the surface of a triangular shape, lie in an almost horizontal plane.

Gen. 3. *Alysidota*, n. gen. Busk.

Char. "Cells disposed in a single series, branching irregularly; one cell arising from another by a broad base. Surface usually punctured."

In the 'Brit. Mus. Cat.' of Marine Polyzoa, p. 82 (Pl. XCII., figs. 1, 2, 3), a species of *Lepralia* is described, and figured under the specific name *L. labrosa*, in which the cells are disposed for the most part in linear series, branching out irregularly from a central point, where some of the cells are crowded together without any definite order. In the absence of other forms having a similar mode of growth, it seemed better to include this species under *Lepralia*, of which it might be regarded as an aberrant form, and to which, at any rate, it appeared to be very closely allied, than to erect it into the type of a distinct generic group.

Lately, however, we have been furnished by Mr. J. Alder, with another form apparently very closely related to the above in its mode of growth; and it would now seem justifiable to constitute of these dendritic polyzoaries a separate, perhaps subgeneric group, of which *L. labrosa*, Busk (' Brit. Mus. Cat.,' p. 82, Pl. XCII., figs. 1, 2, 3), would form the type. The name is taken from the chain-like disposition of the cells.

The genus differs from *Lepralia* in the disposition of the cells, which are, for the most part, arranged in linear series, branching out in various directions in a dendritic manner. From *Hippothoa*, it is distinguished by the circumstance, that the cells arise from each other by a broad base, and are not

contracted below into a tube, and that the branches are given off more irregularly, and not from the sides of the cells, but from the upper and back part of the cell from which they spring.

1. *A. Alderi*, n. sp. Busk. Pl. IX., figs. 6, 7.

Cells ovate broad, surface punctate, verrucose round the border; an umbo in front. Mouth circular with a sinus in the lower border, margin very slightly thickened. Ovicell globose, keeled in front, with a small central umbo.

3 Gen. *Eschara*, Ray. ('Brit. Mus. Cat.' p. 89.)
* Foliaceous.

1. *E. cribraria*, Johnston. Pl. X., figs. 7, 9.

Cells punctured, oval or rhomboidal, the aperture in the mature one with a blunt mucro below; an avicularium on each side of the mouth. Mouth orbicular, margin simple, thin.

Hab. Berwick Bay, 35 fms, *Dr. Johnston*; Coast of Northumberland, deep water, *A. Hancock*, *W. King*, *J. Alder*.

The beautiful *Eschara* here figured, appears to correspond so closely with Dr. Johnston's description of *E. cribraria*, that there would appear to be little doubt of its really being the form understood by him under that appellation. His figures, however, are bad, and seem to have been taken from an old or worn specimen, and it is not easy to reconcile them with his verbal account.

The species was first brought to my notice by Mr. J. Alder, who kindly furnished me with the two smaller specimens figured in the plate, and, at the same time, was good enough to supply outline figures of the larger growths there shown. He informs me that several specimens of it exist in the Newcastle Museum, where they were placed by Mr. King, and labelled *E. foliacea*; he states, also, that Mr. A. Hancock obtained it, many years ago, by dredging in deep water. The mode of growth of the young polyzoary is remarkable. It clasps, by a contracted base, the branch or branches of a *Sertularia* or *Fucus*, and the two planes of cells turn round the support, and apply themselves back to back. This mode of origin, however, is not altogether peculiar; for it obtains in more than one other species of *Eschara*, an instance of which may be seen in *M. Edwards*, *Sur les Eschares*, Pl. III., fig. 1 *d*, in the case, undoubtedly, of *E foliacea*.

2. *Polyzoa cyclostomata*.

Gen. 1. *Alecto*, Lamx.

1. *A. granulata?* W. Thompson. Pl. IX., figs. 1, 2.

The figure is taken from a drawing by Mr. J. Alder of a specimen apparently of the above species, exhibiting a peculiar mode of growth, growing on a stone from Shetland. It bears a close resemblance to *Alysidota*.

ZOOPHYTOLOGY.

DESCRIPTION OF PLATES.

Plate IX.

Fig.

1.—*Alecto granulata?* natural size.

2.— Id. magnified. J. Alder, del.

3.—*Lepralia ringens.*

4.—Single cell, more highly magnified.

5.—Surface of cell more highly magnified. J. Alder, del.

6.—*Alysidota Alderi,* natural size.

7.—Portion magnified. J. Alder, del.

8, 9.—*Lepralia fissa.*

10.—Young cell from edge of patch.

Plate X.

1, 2.—*Lepralia lata.*

3, 4.—*L. unicornis.*

5, 6.—*L. Peachii* (var. *labiosa*).

Plate XI.

1, 2.—*Lepralia pallasiana* (var. *armata*).

3.—*L. Landsborovii?*

4, 5.—*L. punctata?*

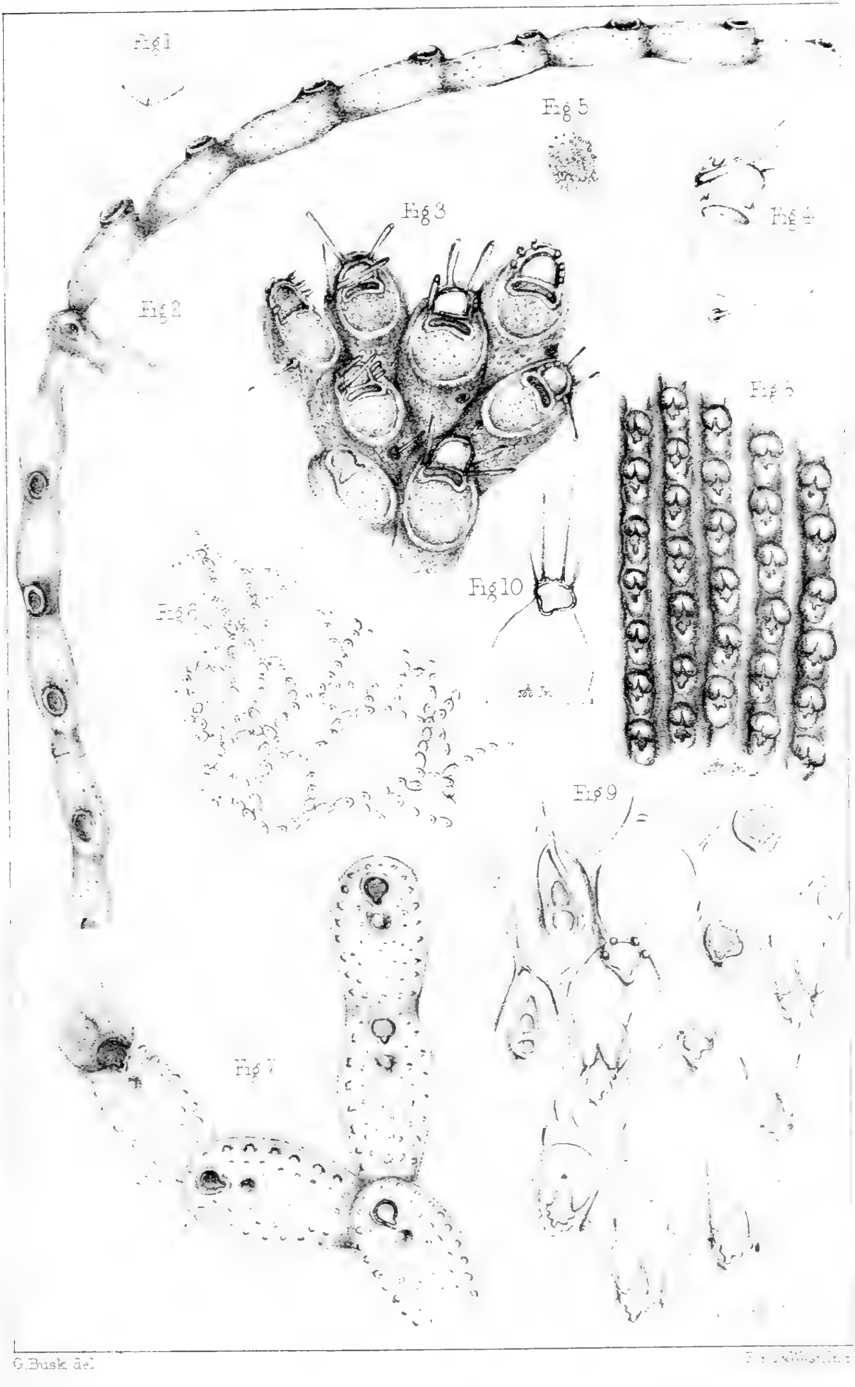
6, 7.—*L. californica.*

Plate XII.

1, 3.—*Eschara cribraria.*

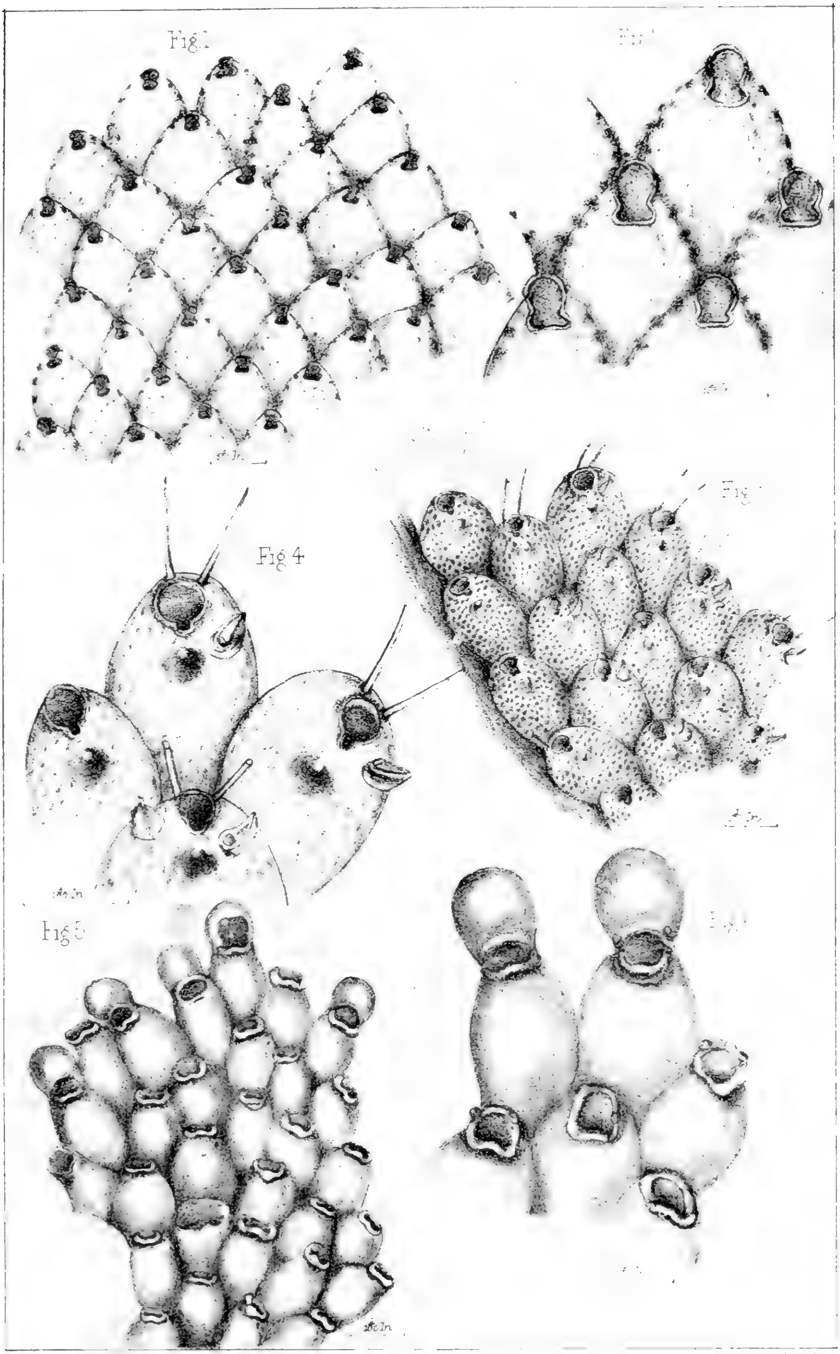
4.—*Membranipora hexagona.*

Plate, IX.



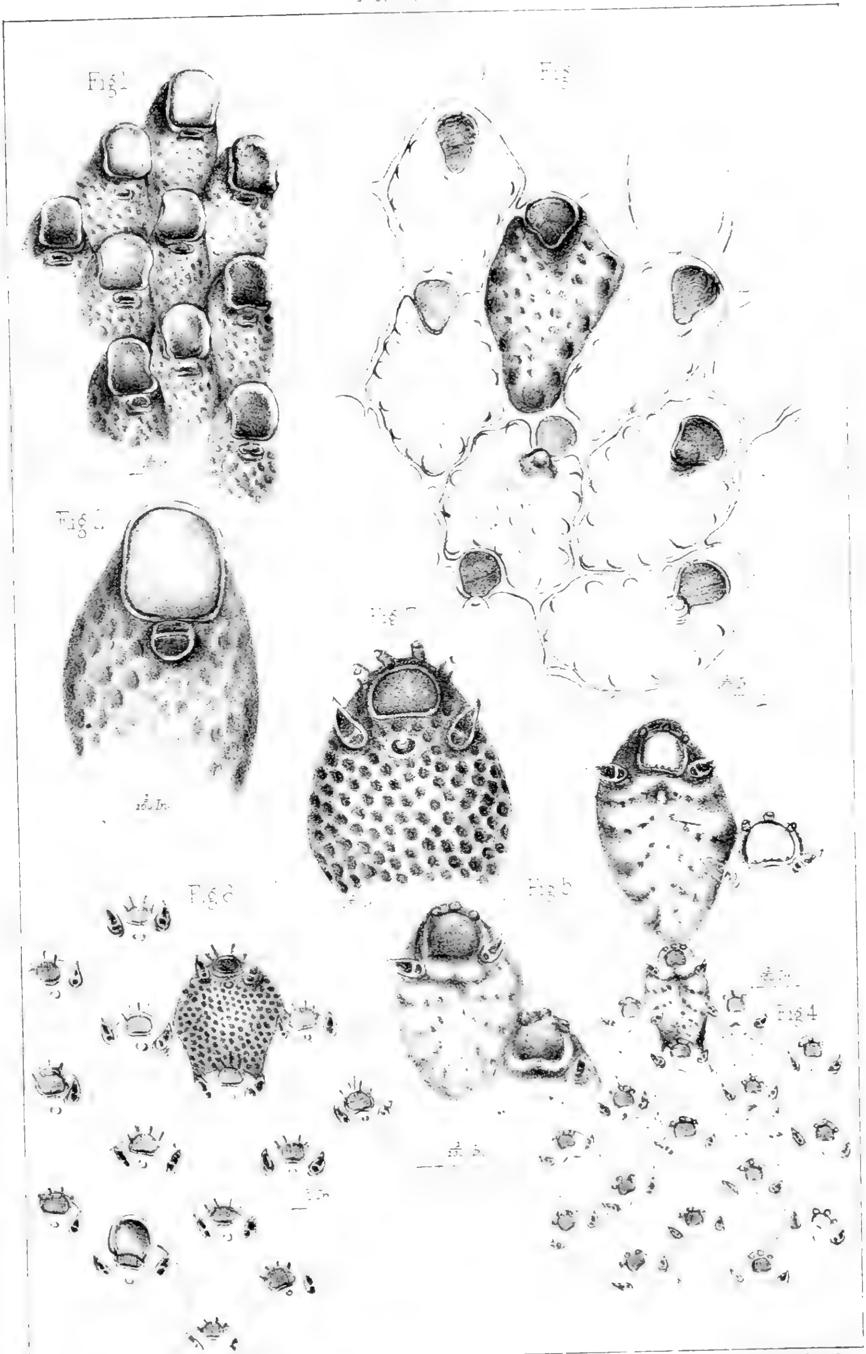
G. Busk del.

Plate X



G. Busk, del. Ford & West, Imp.

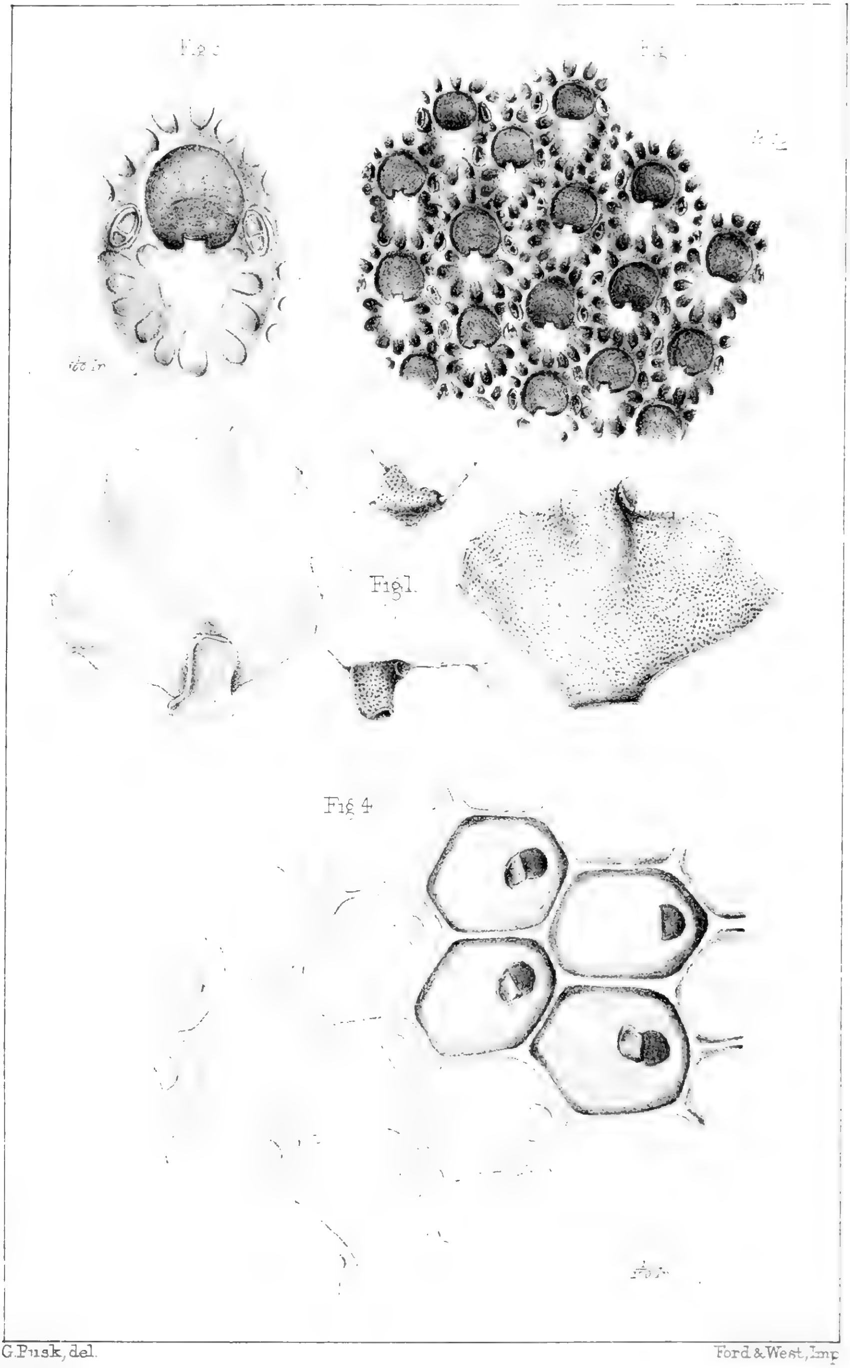
Plate II



G. Busk. del.

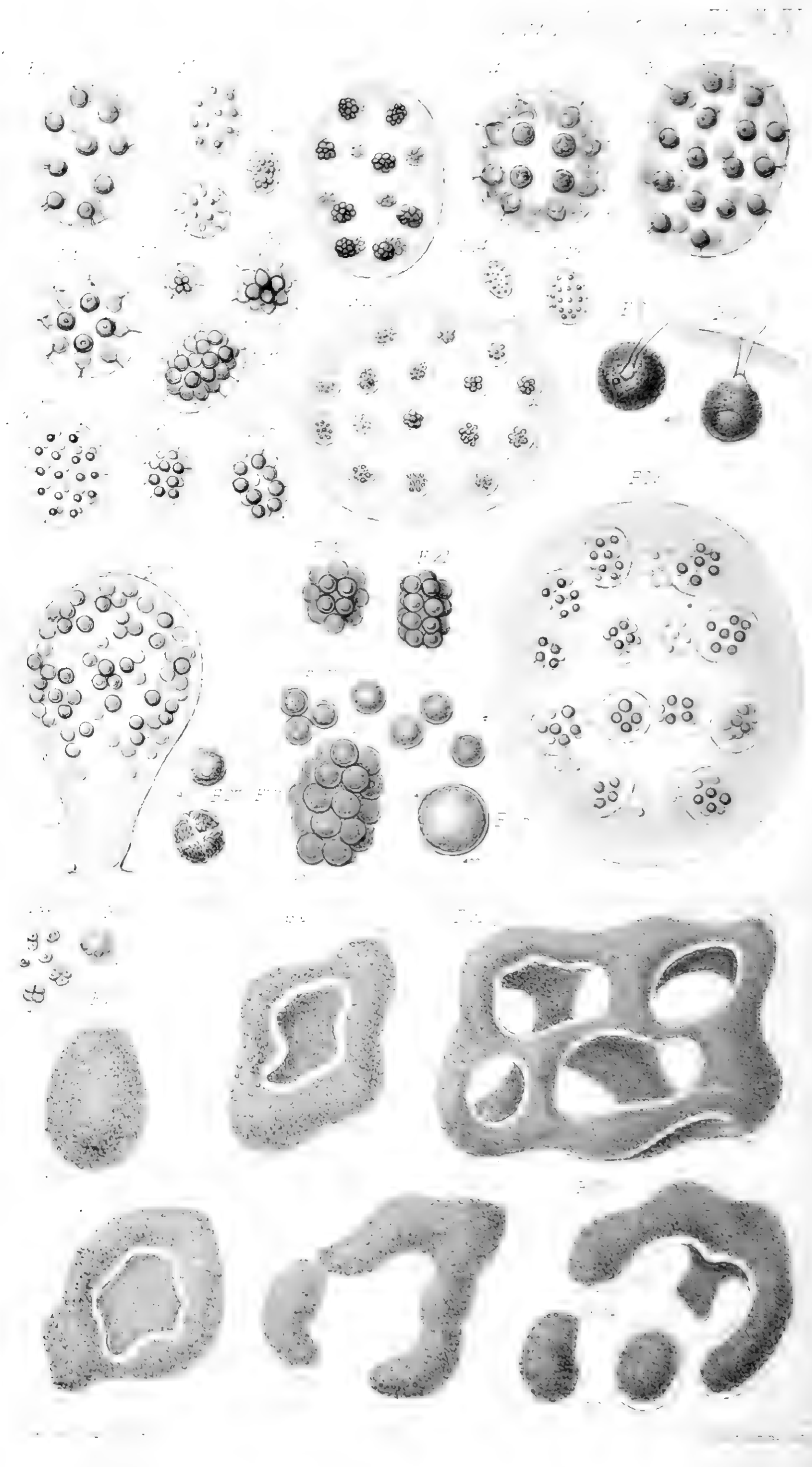
Ford & West, Imp

Plate, XII.



G. Busk, del.

Ford & West, Imp.



DESCRIPTION OF PLATE IV.,

Illustrating Professor Henfrey's paper on some Fresh-water Confervoid Algæ, new to Britain.

Figs. 1—25, *Pandorina Morum*, Ehr.

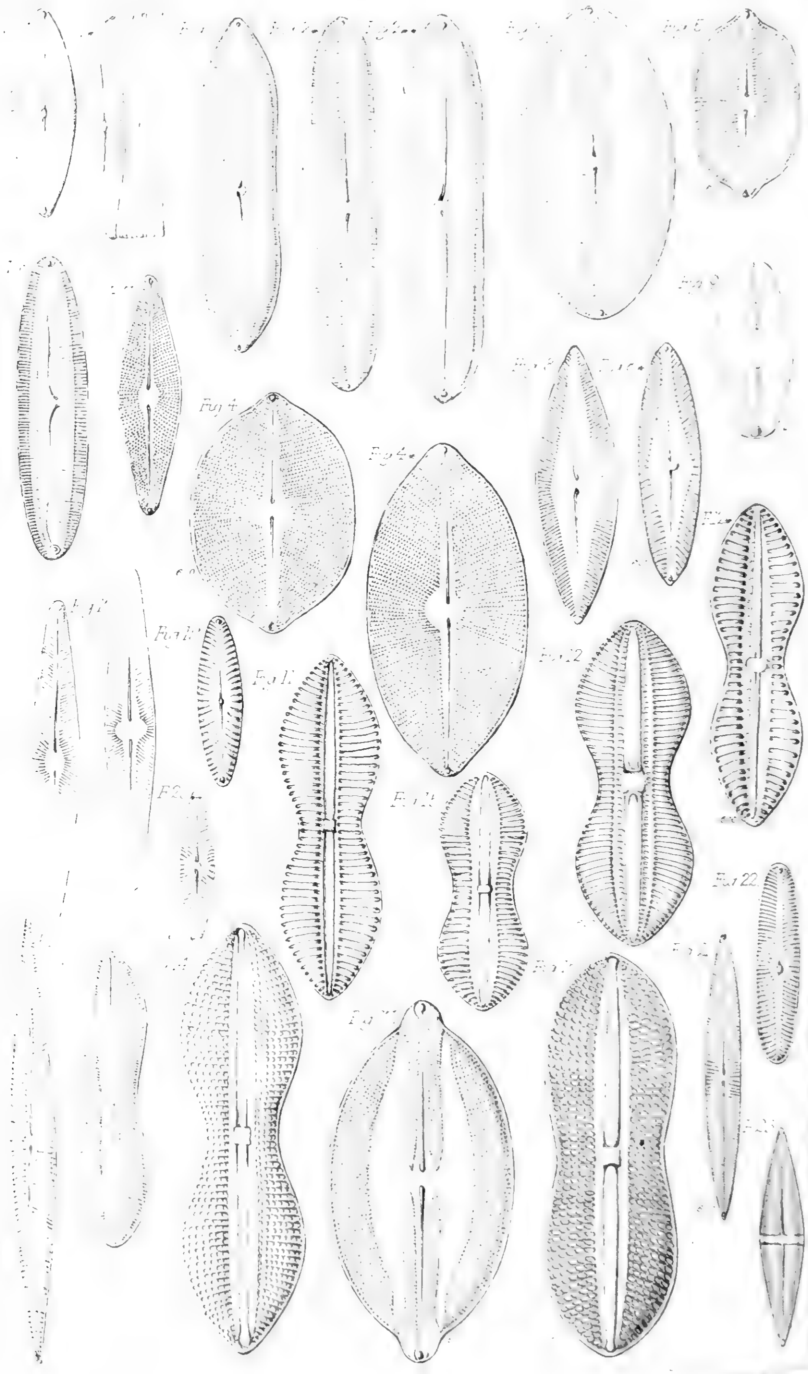
Fig.
1—Perfect form, with 16 gonidia, side view.
2.—Ditto, polar view.
3.—Perfect form, with 32 gonidia, side view.
4.—Ditto, polar view.
5.—A gonidium, side view.
6.—Ditto, from above.
7 and 8.—Side and end view of a small frond, with 16 gonidia.
9.—Side view of a small frond, with 32 gonidia.
10.—A frond, with the gonidia dividing.
11.—A more advanced frond.
12.—A frond, with the young ones nearly perfect.
13 and 14.—Young fronds free.
15 to 20.—Side and end views of fronds, with the gonidia pushed close together.
21.—Side of a frond, like fig. 15, with the gonidia encysted, their contents turned red, and the gelatinous envelope nearly dissolved.
22.—End view of the same.
23.—Side view of one with 32 gonidia, more magnified.
24.—Resting-spores (encysted gonidia) free.
25.—One more magnified, to show the membranous coat.

Figs. 26 and 27, *Apiocystis Brauniana*, Nägeli.

26.—A half-grown frond.
27.—Green gonidia from the interior, the lower ones dividing.

Figs. 28—36, *Clathrocystis æruginosa*, Henfrey.

28 to 31.—Successive stages of development of a frond.
32 to 34.—Fragments of a broken-up frond, like fig. 31.
35.—Green cells from the interior of the gelatinous fronds, some undergoing division.
36.—One more magnified, to show the membranous coat.



DESCRIPTION OF PLATE V.,

Illustrating Dr. Gregory's paper on the Glenshira Sand.

Fig.
1.—*Navicula rhombica*, n. sp. A frequent variety; S. V.
1*.— ,, ,, Front view, showing several grouped in a pack.
2.—*N. maxima*, n. sp. 2*.—Ditto, narrow variety. 2**.—Intermediate form of *N. maxima*.
3.—*N. Hennedyi*, Sm. (Not figured in Synopsis, vol. ii.)
4.—*N. latissima*, n. sp. 4*.—Ditto, longer variety.
5.—*N. quadrata*, n. sp. (= *N. humerosa*, Bréb.)
6.—*N. formosa*, n. sp.
7.—*N. pulchra*, n. sp.
8.—*N. angulosa*, n. sp.
8*.— ,, β.
9.—*N. Macula*, n. sp.
10.—*N. solaris*, n. sp. 2 figures.
11.—*N.? Pandura*, Bréb. (?).
12.—*N.? nitida*, Sm.
12*.— ,, ?
13.—*N. incurvata*, n. sp.
14.—*N. splendida*, n. sp.
15.—*N. didyma*, γ. Costate striæ.
16.— ,, , δ. A new variety.
17.—*N. clavata*, n. sp.
18.—*Pinnularia longa*, n. sp.
19.—*P. fortis*, n. sp.
20.—*P. inflexa*, n. sp.
21.—*P. acutiuscula*, n. sp.
22.—*P. Ergadensis*, n. sp.
23.— *Stauroneis amphioxys*, n. sp.

The figures in this plate represent, for the most part, full-sized or large individuals under a power of 400 diameters. No. 9, *Navicula Macula*, is represented under a somewhat higher power; but I believe there are individuals of equal size under 400 diameters.

The remainder of the new forms which I have described in the Glenshira Sand, and several of which are very curious, will be figured in the next Number of the Journal.

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DESCRIPTION OF PLATE XIV.,

Illustrating Dr. D'Alquen's paper on the Structure of Oscillatoria.

Fig.

1.—Portion of a filament of *Oscillatoria contexta*, showing the striated proper cell-membrane.

2.—A detached empty piece of this cell-membrane.

3.—Portion of filament treated with iodine.
- *a.* Entire portion.
- *b.* Proper cell-membrane slightly affected by the reagent.
- *c.* The plain unstriated cellulose sheath or tube.
- *d.* Single joint on end.

4.—Portion of filament treated by weak syrup.

5.—Ditto by a strong solution of chloride of calcium.

6.—Ditto by a weak ditto.

7.—Ideal section of a filament, showing the concentric arrangement of its different tissues.
- *a.* Vertical section.
- *b.* Horizontal section.
- *c.* Solid axis.
- *d.* Layer of protoplasm coloured by chlorophyll.
- *e.* Proper cell-membrane.

8.—Portion of filament, displaying the manner in which the cell-contents are sometimes observed to separate while under the action of iodine.

9.—*a.* Portion of filament.
b. The same as seen on end, having the appearance of a lenticular disk.

10.—Portion of filament after desiccation and treatment by iodine, showing the shrunken axis of the filament in the form of a green thread.

11.—Ditto not dried, showing this thread between the separated portions of the filament.

12, 13.—Filaments with modified cells representing gonidia.

14.—A new species of *Oscillatoria*, having its cells not coloured by chlorophyll.

15.—The same, with some of its cells filled out.

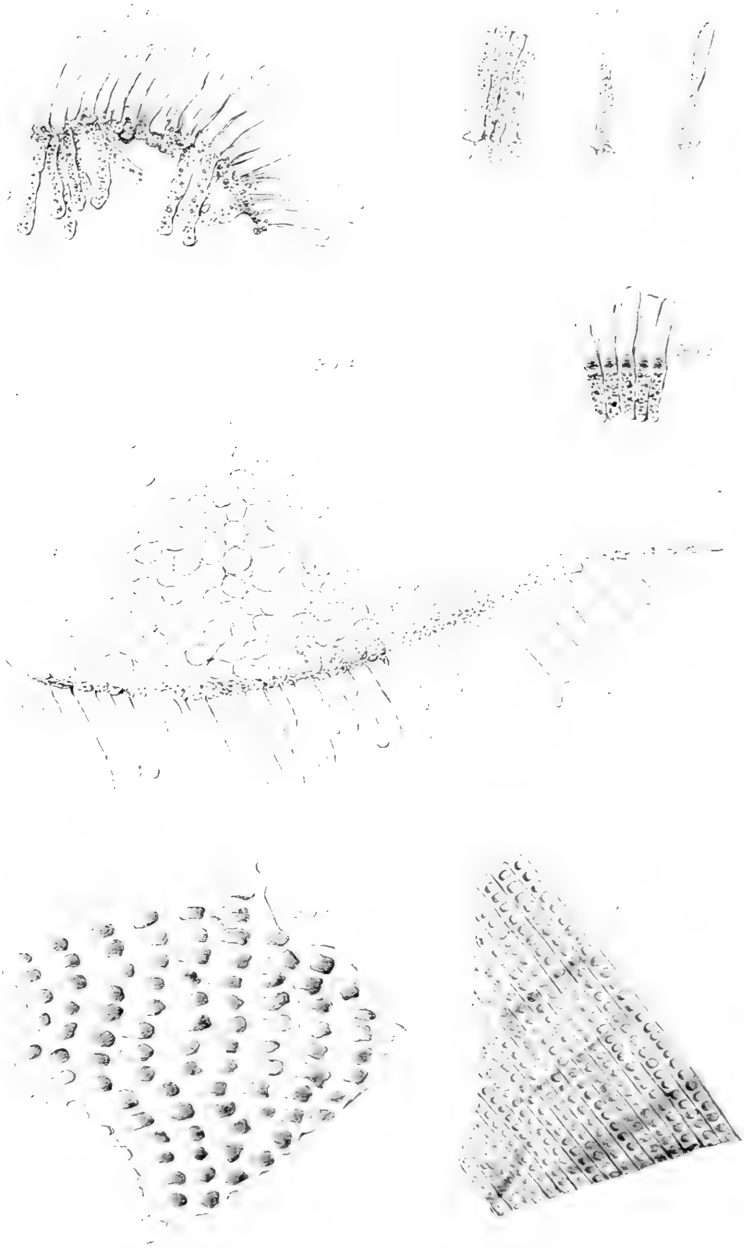
Illustrating Dr. Lankester's paper on Fungi in drinking water.

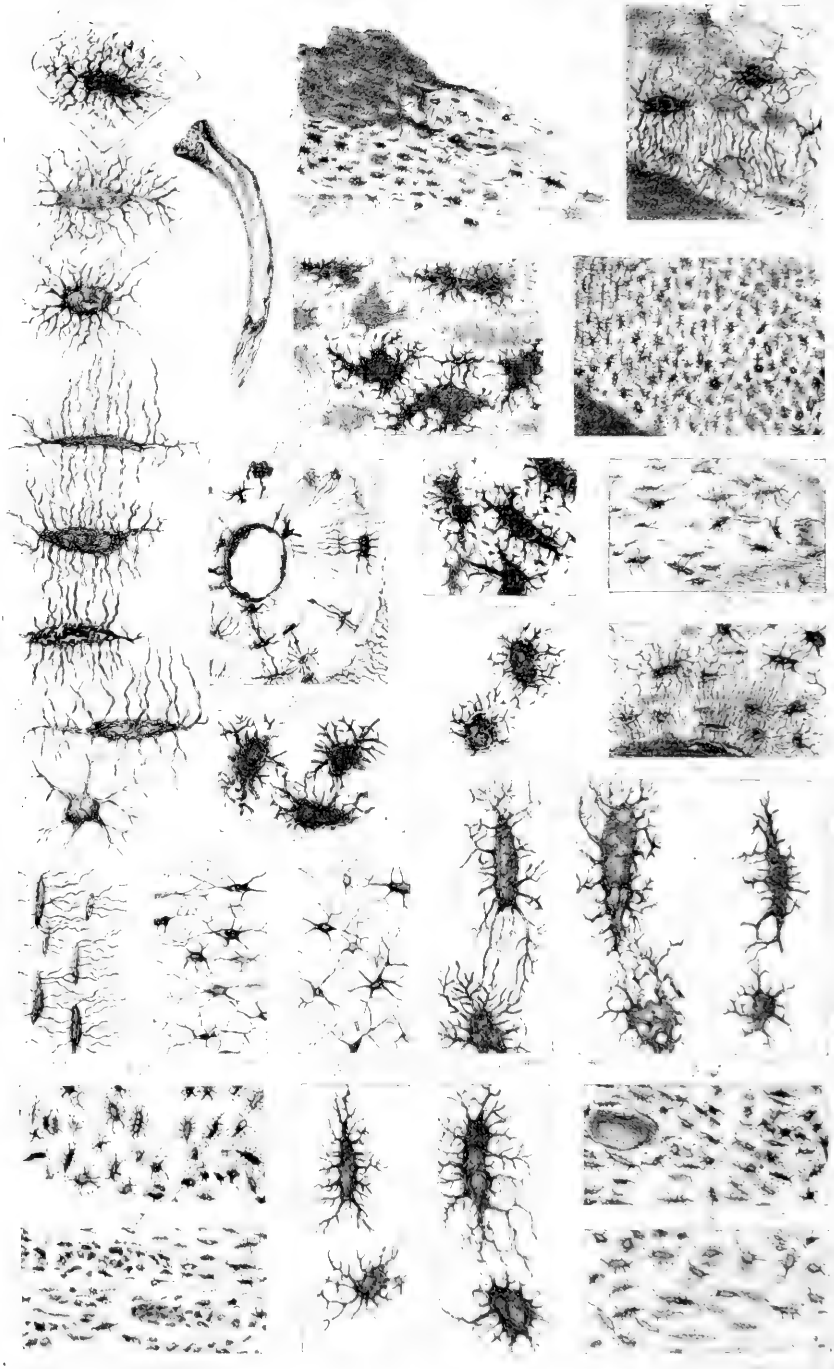
16.—Mycelium of Fungus. *a*, enlargements seen on larger branches.

17.—Particles passing through the branches of the Mycelium.

18.—Spore case of the same Fungus.

19.—Mycelium of a Fungus. *b*, moving particles.





DESCRIPTION OF PLATE XVI.,

Illustrating Rev. J. B. P. Dennis's paper on a Fossil Bone, supposed to be Mammalian.

Fig.

1.—Represents the fossil rib from Lyme Regis. Natural size.

2.—Tangential section. Magnified 100 diameters.

2 *a*.—Portion of the above, at *a*, showing the character of the lacunæ and canaliculi, in connexion with an haversian canal. Magnified 400 diameters, for comparison with fig. 8.

2 *b*.—Portion of fig. 2, at *b*. Magnified 400 diameters.

3.—Longitudinal section of the Lyme Regis bone, magnified 100 diameters, to show the general arrangement of the lacunæ.

4.—Single lacuna of fossil. Magnified 400 diameters.

Figures A to G represent typical lacunæ under the same degree of enlargement.

A. Human. B. Tiger. Mammalian. C. Boa Constrictor. D. Crocodile. E. Fossil Saurian from Stonesfield. F. Turtle. Reptilian. G. Conger Eel. Fish

5.—Fossil Saurian from Stonesfield. Magnified 100 diameters.

6.—Lyme Regis fossil, vertical. Magnified 400 diameters.

7.—Tertiary Mammal. Magnified 400 diameters.

8.—Walrus, transverse; lacunæ in the neighbourhood of an haversian canal. Magnified 200 diameters.

9.—Fossil Cetacean. Magnified 400 diameters.

10.—Fossil Elephant. Magnified 400 diameters.

11.—Ant-eater. Magnified 400 diameters.

12.—Sloth. Magnified 400 diameters.

13.—Dolphin. Magnified 400 diameters.

14.—Dugong. Magnified 400 diameters.

The resemblance of this latter to the fossil in question is very striking.

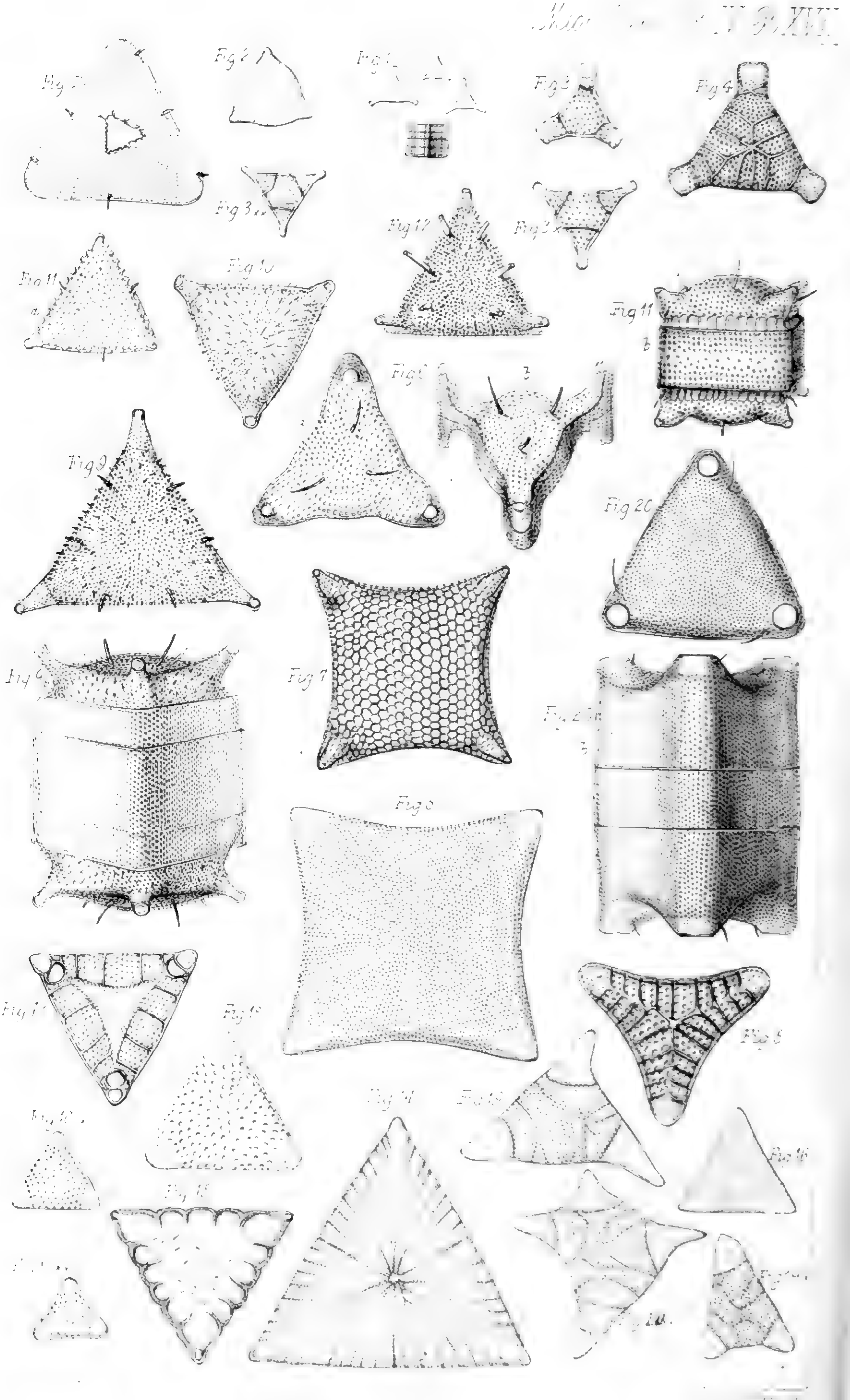
15, 16, 17, 18.—Ant-eater, Sloth, Dolphin, and Dugong, magnified 100 diameters, to show the general arrangement of the lacunæ and canaliculi.

19.—Crocodile, transverse. Magnified 200 diameters.

20.—Toad, tibia, vertical. Magnified 200 diameters.

21.—Sturgeon fin, vertical. Magnified 200 diameters.

22.—Fossil fish (*Pycnodontus*), from Stonesfield.



DESCRIPTION OF PLATE XVII.

Illustrating Mr. Brightwell's second communication on the Genus *Triceratium*.

Fig.

1.—*T. exiguum*, W. Sm. *b*, front view.

2.—*T. parmula* (n. sp.)

3.—*T. brachiatum* (n. sp.)

4.—*T. truncatum* (n. sp.)

5.—*T. venosum* (n. sp.)

6.—*T. coniferum* (n. sp.). *b*, partial front view.

7.—*T. Farus* β.

8.—*T. formosum* γ.

9.—*T. armatum*, Roper. 9 *b*, front view. Dr. Bailey's figure of *T. setigerum* (Smith's Contr. 1854) very strongly resembles ours.

10.—*T. armatum*, α.

11.— ,, β. 11 *b*, front view of a four-sided specimen.

12.— ,, γ.

13.—*T. marginatum* (n. sp.)

14.—*T. radiatum* (n. sp.)

15.—*T. Tabellarium* (n. sp.)

16.—*T. hyalinum* (n. sp.)

17.—*T. Marylandicum* (n. sp.)

18.—*T. punctatum* (n. sp.)

19.—*T. variable* (n. sp.) Three of the very numerous and bizarre forms of this curious species are represented.

20.—*T. orbiculatum*, Shadbolt. *b*, front view.

* The figures are all magnified 400 diameters, with the exception of figs. 5, 6, 7, 8, 9, 10, 12, 13, 14, 20, which are only × 300.

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LONDON: PRINTED BY W. CLOWES AND SONS, STAMFORD STREET.

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OF THE

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OF

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1856.

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VOLUME IV.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET AND CHARING CROSS.

TRANSACTIONS

OF THE

MICROSCOPICAL SOCIETY

OF

LONDON.

On the Formation *and* Development *of the* Vegetable Cell.

By F. H. Wenham.

(Read November 28th, 1855.)

The favourable manner in which my paper on 'Sap Circulation,' published in the last 'Journal of Microscopic Science,' has been received, by some of the most eminent members of this Society, has encouraged me to bring directly before the present meeting the result of investigations on the origin and first formation of the Vegetable Cell.

As I have admitted that I take up the microscope only occasionally, as a means of recreation rather than a special study, it may probably appear great presumption in one, comparatively unpractised, to make a statement of investigations that stand in opposition to the opinion of the distinguished observers who have written upon this self-same subject, after many years of observation, aided by an intimate knowledge of the researches of others in a similar department. I must state, therefore, that I write with due submission, and in the hope that some of the facts mentioned herein may contribute towards the promotion of science, if only by directing attention towards a field of investigation, which, in my opinion, is yet comparatively unexplored.

Feeling that many who take up the study of a particular department of physiological science for the first time will agree with me, I cannot refrain from protesting against the excessive predilection that most professed writers exhibit, in applying technical phraseology to a new branch of science even in the earliest stages of discovery. From this mistaken display of scientific pedantry, the uninitiated are probably at first quite unable to comprehend the matter; and worse than this, an inappropriate name is frequently applied to a circumstance or imaginary substance, having a doubtful, or at least

not a very general existence, and this name is continued throughout the whole series of subjects to which the science relates, often giving rise to a maze of hypothesis. I make the remark because the physiology of the vegetable cell is an example of this. Let any one desirous of knowing in what manner the cell is said to be first formed, take up the elaborate works on the subject by the continental writers, he will find it there stated that an universal and necessary condition of the existence of the cell is the first formation of a central nucleus, termed the "cytoblast." Around this is next formed a membrane which eventually encloses the cell contents, this is named the "primordial utricle," and by the division and duplication of this, successive cells are supposed to be accumulated.

The primordial utricle is a necessary condition in the anatomy of some unicellular plants, such as the *Desmidieæ* and *Algæ*, for, in these instances, the folding inwards of this important membrane causes a constriction of the contents of each cell, and a reproduction and multiplication by self-division; but the same analogy cannot be extended throughout the vegetable kingdom, in those cases where a system of cells have a mutual dependence upon each other. In unicellular plants each cell is one in its most complicated condition, and capable of continuing its existence as a separate plant, independently of others, and is therefore provided with special organs requisite for this peculiar mode of growth.

Those microscopists who, like myself, experience the most fervent delight in reading a page directly from the book of nature, may resort to their microscopes again and again in the hope of witnessing the first creation of the vegetable cell, in relation to the acting conditions of the cytoblast and primordial utricle. The search may be carried from tree, shrub, flowers, or fruit, and be alike in vain. No direct ocular evidence will be obtained of the existence of this nucleus and membrane, and the attempt is abandoned at last, perhaps not without some feelings of humiliation at the supposed unskilful manipulation, that failed to discover facts, believed to have been firmly established.

Before proceeding to describe the formation of the vegetable cell, I must premise that I am fully aware that the interests of science are not to be promoted by controversy based entirely upon mere hypothesis; I have, therefore, carefully avoided this. The illustrations were drawn directly with the camera lucida in exact conformity with the originals, and I have confined myself entirely to what I have seen; but this course will not perhaps justify the assumption of a dog-

matical position, for in microscopical investigation there is some risk in even trusting solely to the evidence of eyesight, and it frequently happens that a series of real facts may be so arranged as to form the basis of a false theory.

In the last number of the 'Quarterly Journal of Microscopical Science,' I described an instance wherein I had observed the growth and thickening of a cell wall to be caused by the deposit of a mass of active corpuscles, the so-called protoplasm.* It is from this mysterious vital substance that all the cell tissues of the vegetable world are built! The starch and chlorophyll contained in the cell cavities, are also seen to derive their increase of bulk by the deposit of the same material. If any portion of a vegetable tissue (particularly if consisting of a group of young cells) be placed in the compressor with a very small quantity of water, and examined under a high power, by applying sufficient force the mass will burst, and as the protoplasm flows forth the following peculiarities may be observed. It is not soluble in water, but only diffuses itself therein; it is in all cases materially composed of active particles, the size of which differ extremely in various plants; in some of the lower Cryptogamia, the particles constituting the protoplasm are exceedingly minute, but with a large aperture and good illumination the whole is still seen to be chiefly composed of an assemblage of active molecules.

Protoplasm, when flowing from the living plant into the surrounding water, exhibits a remarkable tendency to separate itself into cavities and ramifications, which speedily acquire some degree of consistency, apparently from the formation of a membrane, by the partial coagulation of the external portion exposed to water. When the ramifications become so much attenuated, as only to allow the passage of a few active particles at a time, the lateral vibrations of these become restricted, and they travel some distance either backwards or forwards, in a manner very much resembling a single current of sap in the living vegetable cell. At the point where the cells have been ruptured, the protoplasm will sometimes form a membraneous tube, through which the discharge takes place.

Protoplasm exists in a dormant state of vitality in seeds and dried roots, and many pollen granules appear to be simple vesicles filled with this substance, the molecules being more decidedly marked for partial drying. When a pollen grain

* The substance termed sarcode, composing the vital tissue of some of the lowest orders of animals (such as *Hydra viridis*), bears a remarkable resemblance, in some respects, to vegetable protoplasm.

has been deposited in the plant ovule, the occurrence of a cyclosis or circulation is said to have been discovered, passing through the channel of communication that is formed between the granule and embryo sac. This I have not yet witnessed. Whether the protoplasm contained in vegetable cells is endowed with the property of fertilization, I am not able to affirm, unless the following circumstance can be taken as evidence of the fact. During the conjugation of some of the *Algæ* and *Desmidieæ*, the contents of two cells are expelled, and first unite in the form of a shapeless mass; the accompanying protoplasm is now seen to extricate itself from intervening particles, and envelope the whole of the ejected endochrome with a gelatinous-looking sheath. All irregular projections are next drawn inwards, and the mass acquires a spherical or ovoid form. The exterior of the layer of protoplasm is then converted into an investing membrane, and finally a perfect sporangium is the result.

The point that I wish to direct attention to is this. If just at the time that the combined masses of endochrome are assuming the spherical shape, the lid of the compressor used for the observation is repeatedly raised and lowered, so as to wash away the investing layer of protoplasm, the mass of endochrome will retain its ragged outline, without alteration, for many successive days, and a sporangium will not be eventually formed, thus showing that it is the living protoplasm that imparts the principle of vitality to the germ, and also arranges the cell contents in the proper course of symmetry and order.

There are some remarkable movements of corpuscular activity to be observed in some seeds, mainly due to the presence of protoplasm. If a very thin slice of horse chestnut is moistened with a small quantity of water, and covered with thin glass, after about one hour's duration the motion will be in full force. The whole field of view is filled with active granules of protoplasm, and also of starch, in all stages of growth, the most minute of the latter being possessed of molecular motion. There are some spots in the fluid not to be distinguished from the surrounding medium, either by difference of density or any other indication, and which yet cause a very peculiar action, for when the active particles approach these places they are whirled rapidly past. Sometimes a molecule will suddenly start forward and shoot straight across the field of view with considerable velocity, dashing others out of its course. This oftentimes happens when two have become adherent, and occasionally several will be linked together in the form of a spirozoid, which

screws its way through the water with a somewhat uniform speed.*

Having briefly noticed some of the properties of protoplasm, I will proceed at once to the main subject of my paper. I have selected the *Anacharis Alsinastrum* as one of the subjects of investigation, chiefly on account of the magnitude of the vital phenomena, and also because the perfect transparency of the walls of the cells permits their internal movements to be seen without impediment in the earliest stages of growth, the action continuing under considerable mutilation

* Fearing that I am digressing too far from the direct title of this communication, I append this note, submitting some further remarks on corpuscular motion. When a single active molecule is in an isolated position, its vibrations occur spontaneously and at random in all directions; but when a number are combined together in a line of narrow compass, if they have a tendency to mutual entanglement or adherence, as in the instance of the component gelatinous corpuscles of protoplasm, the *longitudinal* vibrations are restricted, and the atoms are compelled to move from side to side, or transversely. This occasions a waving or serpentine movement of the thread-like current, which causes the whole to travel in a *straightforward direction*; thus accounting for the circulation in the vegetable cell. In some plant cells a thread of protoplasm, consisting of a single line of particles, displays in its appearance such a remarkable analogy to a single cilium, that I am inclined to consider the *seminal filament*, attached to some vegetable spores, as a simple line of conjoined active corpuscles, the lateral vibrations of which cause the undulating and progressive motions of the filament.

I cannot at present call to mind any instance wherein a strictly *vegetable* cilium is possessed of a *permanent* existence. After its first temporary office is fulfilled, as an organ of locomotion, for propelling the vital spore to another locality, it speedily becomes disorganised, and disappears.

On the other hand, the animal cilium, used either as a prehensile or motile organ, is far more complicated. It is endowed with permanency, and capable of renewal in cases of injury.

As a matter of conjecture, I offer a remark on those minute bodies termed spizilla, or spirozoids, which are found in decomposing vegetable and animal solutions. They are sometimes so irregular in shape, length, and bulk, that I suppose them to be merely associated particles of organic matter linked together. If the component atoms are in a state of molecular activity, the progressive undulations of the filament will cause the helix to turn on its axis, and, in consequence, these corkscrew-like forms advance through the fluid by rotation.

In the paper contributed to the last number of this Journal by Mr. Busk, we are informed of the fact, that associated vital corpuscles in the living animal possess the same tendency to travel in a direct forward course as in the vegetable cell:—page 22: "A remarkable circumstance observable in the spermatic cavities of *Sagitta*, is the continual cyclosis performed by their contents. These will be seen constantly ascending on the outer, and descending on the internal wall, or septum." I have sometimes seen a cyclosis in the *Rotifera*, in an organ which I presume to be a spermatic vesicle; but this discovery, in a being apparently so highly organised as the *Sagitta bipunctata*, is an important advance into the mysteries of animal creation.

and distortion of form—a circumstance of particular importance.

On dissecting out the centre of the bud at the extreme end of a stalk of the *Anacharis*, a kind of cellular cone will be found, shown Pl. I., at *a*, fig. 1; *b b* are protuberances extending up the sides of the cone, being the germs of future leaves in various stages of growth.

In the first formation of a leaf from the main stem, a small nodule or protuberance appears, which is entirely filled with granular protoplasm. A number of cavities next become disseminated throughout the mass, as represented by fig. 2. These are formed in the most random and irregular manner, both as to size and position—small spaces being indiscriminately mixed with larger ones of perhaps ten times their bulk, much resembling the cavities in a slice of bread-crumb. There is no special means provided for the formation or arrangement of these spaces, neither does it arise from any species of fermentation, but from the inherent property that protoplasm possesses of separating itself from its more fluid admixtures, and forming cavities and thread-like divisions, as chance alone directs.

At this primitive stage there are no travelling currents of protoplasm, a feeble corpuscular motion is all that is to be seen. These cavities are the foundation of the cell formation. Very minute *starch* granules make their appearance in some of them, even at this period, as shown at *a*, *a*, fig. 2. This example was drawn from the *Anacharis*, but it may be taken as the representative of the primary cell formation of the largest portion of the vegetable creation. The first germs of either leaves, flowers, or stems, alike consisting simply of a nodule of irregular diversiform cavities, so nearly similar in shape and arrangement in widely-different species, as scarcely to exhibit any distinctive features of variety, I have selected the following plants to exemplify this:—Fig. 3 is a mass of cells in their first formation, taken from the centre of a bud of *Arabis albida*, with rudimentary cavities appearing in the body of protoplasm at the apex. Fig. 4 is a leaflet from the same plant, with the cells in a rather more advanced stage, each cell containing a few minute nuclei, or incipient starch granules. Fig. 5 is a malformed stellate hair, the base being filled with protoplasm, which, in the upper portion, exhibits a tendency to divide itself into cavities and cells. Fig. 6 is a leaflet of *Reseda*, the apex having burst under the action of the compressor, and the protoplasm had exuded into the surrounding water, in the form of a globule, filled with cavities, shown at *a*, *a*. This accident frequently happens, and may

readily be mistaken for a mass of primary cell formation Fig. 7 is the first formation of a linear leaf of the *Anethum Fœniculum*, bearing much resemblance to fig. 2.

Having shown the analogy between the primitive cell formation of the *Anacharis* and non-aquatic plants, I will now trace the cell in its progressive stages of development, referring from fig. 2. Fig. 8 represents the *Anacharis* cells in a more advanced condition. A general longitudinal extension has taken place throughout the mass, and something like a definite line of cell formation becomes apparent. The cavities contain an increased number of starch nuclei, and are now lined with a distinct wall or membrane, but still, from the thickness of the intermediate substance, the whole structure resembles a number of irregular vesicles or bags, imbedded in protoplasm.

If at this period of growth a portion of the leaflet be subjected to the test of alcohol, the cellulose membrane lining each cavity will separate, and shrink together upon the cell contents. This has probably been mistaken for the so termed primordial utricle; but however this may be, it is, in fact, from first to last, the true cell wall, and is not dissolved or absorbed in any subsequent state of the cell's existence. It thus appears that a bud, instead of starting at first from a single cell, as some have imagined, derives its origin from the simultaneous development of a group of some hundreds. The number of cavities in the primary nodule do not exactly correspond with the number to be contained in the perfect leaf, for wherever there is an accumulated bulk of protoplasm, a space is sure to be formed within it subsequently; new cells are thus continually in the course of formation.

On considering fig. 2 it will become evident that if an uniform distension of the mass should take place, the great disproportion in the bulk of adjoining cavities would create a system of cells, of such monstrous difference in size and length, as to set all symmetry at defiance (well illustrated by the extension of an india-rubber model). The manner in which this difficulty is obviated, and regularity obtained at last, is both simple and beautiful. Fig. 9 represents a series of cells in a more advanced stage of growth. The walls are yet soft, and much exceed their destined and final limits of thickness. At this period cyclosis may be distinctly seen in each cell, all of which now contain protoplasm *within* their walls. In those cells that are exceedingly elongated, and disproportionate in size, the protoplasm accumulates in the middle, and forms a thick septum across, as shown at *a*, *a*, *a*, thus dividing the cell into two. On both sides of the septum

a thin membrane is next formed, which constitutes the end wall of the two cells. The two membranes gradually approximate towards each other, and the intervening protoplasm disappears.

In instances where the cell is of excessive length, a larger mass of protoplasm accumulates midway, in the centre of which a cavity makes its appearance, as at *a*, fig. 10; this enlarges, and becomes lined with a membrane, and thus divides the original cell space into three parts.

A tissue of cells, in the stage of development represented by fig. 9 is nearly colourless; it is about this period that it begins to emerge out of its dark location, so far as to give the first indications of the *chemical action* of light in causing the deposit of chlorophyll instead of starch. The minute granules of starch, previously scattered throughout the cells, serve for the nuclei of the chlorophyll granules. At first they are enveloped in a delicate green coating, which becomes thicker, and more decided in colour, as the cell approaches further into the light. These incipient chlorophyll granules are now frequently carried about in the currents of protoplasm circulating in the cells at this time. A single atom of starch is sufficient for the nucleus of a chlorophyll granule, but sometimes the green coating is deposited simultaneously upon a group of several together.

Fig. 11 represents the cells of a leaf of *Anacharis* in its latest stage of vital existence. The cell walls having now attained their utmost degree of thinness and consistency, the entire leaf acquires a yellow tinge, from the altered colour of the shrunken and partly dissolved chlorophyll granules (hence termed "*xanthophyll*"), which now so far disappear, that some cells contain only two or three, much disintegrated. At this period the leaf cells, though apparently in their first stage of decay, are probably performing their most important functions, by affording nutriment to the growing plant, by the dissolution of their contents. In the specimen here drawn a rapid current of protoplasm was traversing the interior of each cell. This motion is perhaps quite as necessary for the solution of the cell contents as for their formation by successive deposits; in fact, the phenomena of cell circulation are oftentimes best seen at this stage.

I have omitted to mention that indications of a strong endosmotic force are perceptible throughout the entire course of cell formation. The cavities spontaneously formed in an exuded mass of protoplasm sometimes burst from the accumulation of fluid in their interior; many unicellular plants, after being partly dried, will also burst on being again subjected to

moisture, from the infiltration of water into their cells. It is this same force which is chiefly instrumental in causing the distention of the detached vesicle or bag, of which each cell primarily consists, till at last contiguous walls become united throughout the structure. In some instances the force is not sufficient to cause the complete distention and union at the corners, consequently the leaf tissues of many plants are characterized by little angular spaces, occupying the point of union between the confluent walls of neighbouring cells.

It now remains to be asked, if the first origin of all parts of the vegetable structure consist merely of a protruding nodule of protoplasm, containing numerous cavities in size and position most irregular, what is it that determines whether this shall form either a stem, flower, or leaf at last, the first formation being alike for each? The question is a difficult one to answer in all its details, but it may be stated with certainty that the primitive mass possesses *no* inherent power of its own, in either shape or substance, to arrange its destined form of growth. This is dependant entirely upon the influence of the adjoining, and more perfectly developed portions of the plant. In the case of a leaf, the soft cellular mass, while yet growing in the bud, is moulded to something like its proper form by the pressure of other leaflets, and when the cells of the embryo leaf have acquired some degree of consistency, a single spiral duct * is seen to grow out of the parent stem, forcing its way as an axis through the soft assemblage of cells. Others quickly follow, and lateral ramifications extend themselves as form requires. In the case of a leaf, all this may be very readily observed, but the formation of a flower-bud involves far more complicated conditions, with the whole details of which I do not profess to be acquainted. Fig. 12 will, however, serve as an illustration; it is a group of embryo flowers, taken from the *Arabis albida*, during the month of October (the fully developed blossom not appearing until the ensuing spring): *a* is a simple protuberance, filled with protoplasm, in its early stage of cell formation; *b* is a flower-bud, at a more advanced period of growth, the centre being permeated by several spiral ducts and vessels. In the stages *c*, *d*, and *e* the ducts and vessels are still to be discerned, but very much increased in number and complexity; *f* and *g* exhibit all the rudiments of the perfect flower, being apparently made up of

* It has not been explained very clearly how these vessels are formed. By frequently observing their growing end among a mass of young cells, I have imagined that I have detected a disc-shaped cell at the extremity, by the successive formation and subsequent perforation of which the spiral duct is formed; but the first growth is so indistinct and ill-defined, that I cannot at present affirm it with certainty.

thickened and gelatinous-looking masses of cells; *h* are cell prolongations, or the successive rudiments of stellate hairs.

I may remark, in conclusion, that I am aware that some of the facts relating to vegetable growth herein mentioned are not new, but information on this subject exists in so scattered a form that there is some difficulty in making special references.

Addendum.

In order that there may be no misapprehension of my views, with respect to cellular creation, I append the following summary of the succeeding stages:—

The first appearance of the formation of vegetable cells is a simple protuberance filled with protoplasm, alike throughout in substance. This is enclosed by a skin or membrane, the origin of the future leaf cuticle, but which, I presume, at this early period, would be termed the "periplast." A number of irregular cavities (vacuoles), filled with watery cell sap, now make their appearance. These are simply formed by the separation and agglutination of the viscous protoplasm. A thin lining membrane is next developed in the interior of each cavity; this does not become detached at any after period, but is, in fact, the inner stratum of the future cell-wall. The membrane is thickened into a true cell-wall by the direct transmutation into cellulose of the protoplasm existing between, and *exterior* to the cell cavities.

It is not until the cell-wall has advanced to a well-marked degree of development that any protoplasm is generated *within* the cell. This now rapidly makes its appearance, and spreads itself within the cell-wall. Hence arises the question whether this, when in the form of an internal layer, is explicitly understood if termed the "primordial utricle?" In this case primordial is certainly inapplicable, because protoplasm does not make its appearance in the cell cavity before it is somewhat advanced in growth, and sometimes is not even seen, until subsequently to the formation of minute starch granules adherent to the cell-walls.

By the application of a reagent, the protoplasmic layer, from being extremely prone to coagulation, can be made to contract like a membrane upon the cell contents, but I question whether the term membrane, or utricle, is to be properly applied to a motile but viscous fluid, which at times will run together in patches and clots, and leave large portions of the cell-wall bare. There is perhaps no reason against the propriety of the term when applied to some unicellular plants, in which the appearance and uses of such a membrane are so distinctly to be observed.

DESCRIPTION OF PLATE I., VOL. IV.

Illustrating Mr. Wenham's Paper on the Vegetable Cell.

Fig.

1.—End of stalk of *Anacharis alsinastrum.* *b, b.* Germs of future leaves.

2.—Primitive cell-formation of leaf of *Anacharis.*

3.—Primitive cell-formation of *Arabis albida*, with the rudiments of cells appearing at the apex.

4.—Leaflet of *Arabis*, with cells in a more advanced stage.

5.—Malformed stellate hair with the protoplasm at the apex, showing a tendency to cell-formation.

6.—Leaflet of *Reseda* burst at the apex. The exuded mass of protoplasm having become filled with cavities.

7.—Primitive cell-formation of leaf of *Anethum Fœniculum.*

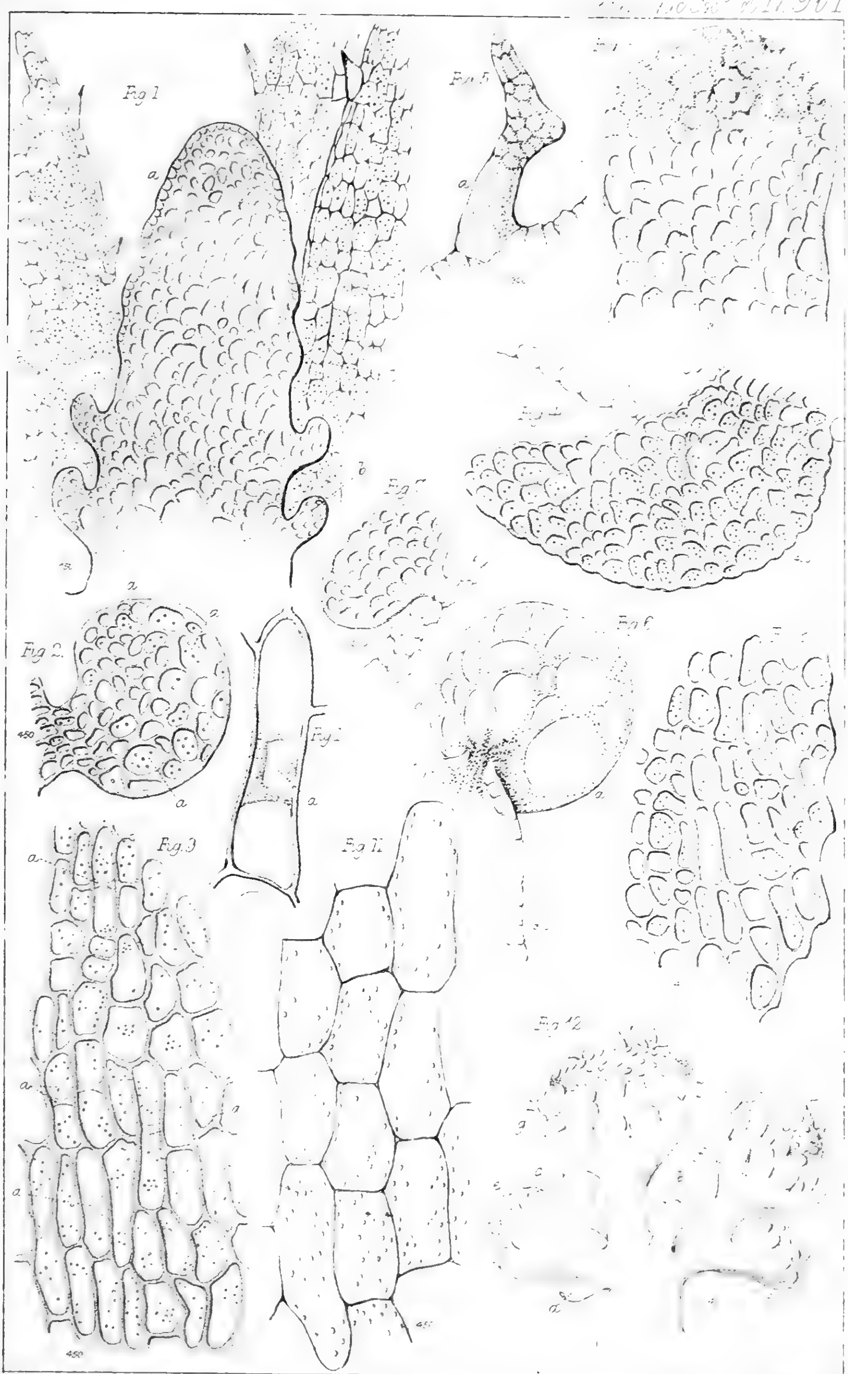
8.—Cells of *Anacharis* in succeeding stage to Fig. 2.

9.—Cells of *Anacharis* in more advanced stage. *a. a.* Septa of protoplasm dividing cells too much elongated into two parts.

10.—Cell excessively elongated with an intermediate mass of protoplasm. *a.* Cavity formed in protoplasm which expands and divides the original cell-space into three parts.

11.—Cells of *Anacharis* in latest stage of growth.

12.—Group of embryo flowers of *Arabis albida.* *a. b. c. d. e. f. g.* Successive stages of development. *h.* Cell prolongations or rudiments of stellate hairs.



F H W del. Tuffen West sc.

A Simple Form of Portable Microscope, *with* Lever Adjustment, *which may be adapted to several different purposes.* By Lionel Beale, M.B., Professor of Physiology and General and Morbid Anatomy in King's College, London.

The Microscope which I wish to bring under the notice of the Society, seems to me to possess some advantages over those in ordinary use in simplicity of construction, in the number of uses to which it may be applied, and in price. The accompanying outline diagrams show the general arrangement of the instrument. The telescope stem, *a*, and horizontal arm, *b*, upon which the body, *c*, is fixed by the aid of a hinge-joint, *e*, are made of brass tubes, about an inch in diameter. Upon the outside of the stem the stage, *f*, and mirror, *g*, are made to slide. The lower part of the stem slides in a tube, *h*, provided with a clamp screw, *i*, so that the whole instrument may be arranged in the erect posture at any convenient height, Fig. 1, Pl. II. If required, the mirror can be fixed upon the lowest part of the stem beneath the tripod at *k*. The tripod stand may be made of cast iron or of brass, and each leg attached with a hinge-joint, which increases its portability. The horizontal bar is prevented from turning round by a ridge, *l*, which is fixed upon its lower surface, and which slides in a groove in a piece of tube attached to the upright by a hinge-joint, *m*. The coarse adjustment consists of a knee-lever, *n*, and in this way a very smooth and steady movement of three inches in extent is obtained. The tube in which the body slides should be longer than that in the instrument exhibited this evening. For the adaptation and manufacture of this lever adjustment I am indebted to Mr. Becker, Philosophical Instrument Maker, of Newman-street. A fine adjustment may be attached in the usual position, just above the object glass, *o*. Upon the front of the body, in its upper part, is placed a small piece of brass, with a number of holes, *p*, in which a small brass pin may be inserted, so that the object-glass may be brought as close to the object as may be desired, and at the same time without any danger of its being forced down upon the object, or through the glass slide placed upon the stage.

Fig. 1 shows the instrument arranged in the erect posture. Fig. 2 in a slanting direction. The horizontal arm, *b*, in this position takes the place of the upright stem. Fig 3 represents the microscope arranged for making minute dissections, a small pin, *r*, prevents the horizontal bar from falling too

low. In fig. 4 the telescope tube is drawn out, and the instrument arranged for examining living animals, &c., in a vivarium.

The various portions of the microscope are readily separated from each other, and can be packed in a small case. The weight of the entire instrument, with case, &c., will probably not be more than six pounds. Mr. Matthews, of Portugal-street, Lincoln's Inn, thinks that this microscope, without powers, can be well made for five pounds, or even less. There is some vibration in the body of the instrument which I have in use, but the lever movement appears likely to answer well for all powers below half an inch; the motion is even smoother than would be supposed. Several slight alterations in the mechanical parts of the instrument have been suggested, and will doubtless add to its efficiency. As a travelling microscope, especially for sea-side work, this arrangement will I think be found very useful, and is not likely to get out of repair.

REPORT

OF

THE SIXTEENTH ANNUAL MEETING

OF THE

MICROSCOPICAL SOCIETY.

THE Meeting was held February 27th, 1856,—Dr. CARPENTER, President, in the Chair. The Assistant Secretary read the following Reports:—

According to annual custom, the Council have to make the following Report on the state and progress of the Society during the past year.

The number of Members at the last Anniversary, was 221, including 6 Associates and Honorary Members. Since that time there have been elected 32, making a total of 253. This number must, however, be reduced by 3 deceased and 9 resigned, making a final total of 241; still showing an increase of 20 upon the number at the last Anniversary. Many new works and objects have been added to the Library and Collections of the Society. There are also in the possession of the Society various drawings and diagrams relating chiefly to papers read at the Meetings, together with copies of the several parts of the Transactions and of the Journal. The state of the finances of the Society will be shown by the following Report of the Auditors, from which it appears that there is a balance in the hands of the Treasurer of 37*l.* 14*s.* 4*d.*

The election of Officers took place, when the following gentlemen were elected:—

Officers and Council.

President . . . . GEO. SHADBOLT, Esq.
Treasurer . . . . N. B. WARD, Esq.
Secretary . . . . J. QUEKETT, Esq.

Four new Members of Council.

DR. LANKESTER.
F. S. C. ROPER, Esq.
R. J. FARRANTS, Esq.
ANTONIO BRADY, Esq.

In the place of

G. C. HANDFORD, Esq.
R. HODGSON, Esq.
REV. J. B. READE.
F. SIMONDS, Esq.

who retire.

From February 25th, 1855, to February 22nd, 1856.

Receipts.

	£.	s.	d.
Balance from the previous year	33	18	6
Entrance fees of Members	25	4	0
Compositions (invested as *per contra*)	31	10	0
Subscriptions received	164	17	0
Transactions sold	3	19	6
Dividends—two half-years' on 329*l.* 16*s.* 8*d.* Consols	9	8	6
	£268	17	6

Payments.

		£.	s.	d.
Rent to Horticultural Society (for one year)		30	0	0
Salary of Assistant Secretary		15	15	0
,, Curator		2	2	0
J. Quekett, Esq., Sundry Expenses		2	12	0
Firing, 2*l.* 15*s.* 0*d.*; Gas 2*l.* 18*s.* 6*d.*		5	13	6
Soirée 10*l.* 14*s.* 6*d.*; Tea at Meetings and Attendance 17*l.* 10*s.* 10*d.*		28	5	4
Stationery, Postage, &c.		6	18	10
Journal, to Messrs. Highley		84	17	6
Ray Society, 12 years' Subscriptions		12	12	0
Commission on Collections		10	18	6
Purchase of 34*l.* 13*s.* 0*d.* Consols		31	8	6
Balance:—				
At Bankers	14*l.* 1*s.* 8*d.*			
In Treasurer's hands	23 12 8			
		37	14	4
		£268	17	6

Robert Warington, } *Auditors.*
R. J. Farrant, }
26th Feb., 1856.

Address of the President.

Gentlemen,—The circumstances under which our Society now meets, bear so close a resemblance to those which existed at its last Anniversary, that we must look upon them, I think, as representing, not a transient condition which it may be left to time to modify, but a persistent state which has grown to be a part of our existing constitution. I think it well, therefore, to place before you, in the best manner I am able, such an honest view of our position as may bring out our weak as well as our strong points, our deficiencies as well as our advantages; and may thus at once suggest remedies for the former, and lead to the still further development of the latter.

Our Report is again most satisfactory in regard to the financial position of the Society. The number of members still continues on the increase, no fewer than thirty-two new members having been elected, whilst we have lost only twelve by death or withdrawal. Our funds have consequently been adequate, not only to supply every member with a copy of the 'Quarterly Journal,' but also to furnish tea for our meetings; and we have also been able to meet without inconvenience an unexpected demand for an arrear of twelve guineas due to the Ray Society.

Our meetings, also, have been almost uniformly well attended; and great benefit has doubtless resulted from the intercommunication which they have promoted between so many who are interested in the same pursuit.

We are far, however, from having similar cause for satisfaction, in regard to the number or the importance of the papers brought before us. The dearth which I last year hoped might be temporary, has increased rather than diminished; and our meetings would have been without anything to occupy them, on several occasions, if means had not been extemporaneously found for supplying the deficiency. Our Transactions for the last year contain but two papers and one short notice; and these, with a paper which it was not thought desirable to include in them, and with the exhibition of Mr. Warrington's and of Dr. Beale's new forms of microscope, constitute the whole of the regular business which has come before us.

Now I cannot but regard the continuance of this state of things as likely to be most prejudicial to the interests of the Society. It would be unreasonable to expect that the attendance at our meetings should keep up, if there be no adequate

prospect of materials for their occupation. That which should be but a subordinate inducement to membership of the Society, the title to receive its publications, seems now to have become the principal attraction; every member, through the arrangement which we have been enabled to make with the proprietors of the 'Microscopical Journal,' having nearly three-fourths of his subscription returned to him in this form. But this arrangement may be determined at any time; since it merely exists so long as it shall be found to work advantageously for both parties. If the proprietors of the Journal should have reason to think that the increase in the number of *our* members causes a diminution in the number of *their* subscribers, they will probably not consider its continuance to be for their interest; whilst, on the other hand, if it should appear that the support which we give to the Journal, so far from promoting our welfare as a Society, has an indirect tendency to weaken us, that support *we* might feel it desirable to withdraw.

I cannot but consider that both the *status* of the Society as a scientific body, which must depend upon the goodness and quantity of the work it does, and the maintenance of its attractiveness and efficiency as a centre of union to those engaged in microscopic research, necessitate the taking of some steps to supply a deficiency which has now become unfortunately but too apparent; and the first and most obvious of these steps consists in the inquiry into its causes. Of these, I shall only specify what occur to myself; others will doubtless be supplied by such as have a more extended acquaintance than I possess with the individual members of our Society.

In the first place, I am disposed to think that the facility of publication now afforded by the 'Microscopical Journal,' has had no inconsiderable influence in diminishing the number of papers sent to the Society.

Formerly our Transactions constituted the only medium through which a microscopist could readily make public, with the requisite illustrations, such results of his inquiries as might scarcely possess the dignity or completeness required for presentation to the Royal or Linnæan Societies. But the Journal now opens its pages freely to all, whether Members of this Society or not; its editors readily admitting every creditable paper, and liberally furnishing the requisite illustrations. Now as our Transactions are published in a form so precisely similar to that of the Journal, as only to be distinguishable by the numbering of the pages, few authors would much care whether their contributions appear in one part of the Number or the other. And yet there *is*,

or there *might be*, a considerable difference in the credit attaching to these two appearances respectively. For the editors of the Journal (having to fill a certain number of pages every quarter) can scarcely be expected to feel that responsibility as to the quality of the papers they insert, which lies upon the Council of our Society, which is charged with admitting into its Transactions only such communications as they may deem possessed of a certain scientific value. As the case at present stands, I cannot but believe that the want of due appreciation of the superior credit of our Transactions, and a feeling of indisposition on the part of authors to subject their communications to the double ordeal of a public discussion and of a privately-considered verdict, have kept, and will continue to keep, many valuable papers from being brought before the Society.

Now if such be really one of the causes of deficiency, the next question is, how can it be remedied? The remedy does not seem to me to be easy, so long as the existing union between the Transactions and the Journal shall continue; and this union is attended with so much advantage to our Members, that I cannot advise its discontinuance. But it has occurred to me that a more marked difference might be advantageously made between our Transactions and the Journal, by adopting a different style for the former,—a somewhat larger type, for example, or a more open page,—which should in some degree mark the superior *status* which I claim for them. The remedy lies essentially, however, with the Members themselves; who ought, I think, to feel under an obligation to promote the interests of the Society, by sending their communications to it, rather than forward them direct to the Journal: and though we can scarcely exert any *compulsion* in such a matter, yet I would have the latter proceeding *dis*couraged, and the former *en*couraged, by the potent voice of public opinion. Further, if we can, by such a distinction as I have suggested, increase the value set upon the appearance of a paper in our Transactions, we might take means to attract to ourselves various communications from sources external to our Society, which at present naturally follow the course of the stream that carries them to the Journal.

Another source of the deficiency in question, appears to me to lie in the desultory mode in which a large proportion of our microscopic observers apply themselves to the use of the instrument. When we contrast the products of British and of German microscopy, and see how completely inverse are the proportions between the values of the instruments em-

ployed, and of the results obtained, in the two countries respectively, we cannot but feel some shame at the low position we take. Now it may be said, that there are so many more in Germany who can make microscopical observations a special object of pursuit, devoting to it a large proportion of their whole time, than there are in this country, that the difference in result is not to be wondered at. But this I feel satisfied is by no means the whole of the cause of difference; for if those among us who are able to give but a few hours a week to microscopic research (which has been almost constantly my own case), would but apply those few hours to the prosecution of some definite department of study, they would come to feel, I am confident, a far higher interest in their pursuit, and would be in a far more favourable position to add something to the common stock of knowledge, than by expending their time in desultory observations. And this will be especially the case, when the student, in the selection of his department, consults his means and opportunities for investigating it, as well as his tastes, so as to protect himself as much as possible from being cramped in his inquiries by want of the necessary material. There is always, of course, a danger that the inexperienced inquirer will not duly interpret what he sees, and that he may draw wrong deductions where he observes aright; but this danger is greatly diminished when he confines his attention within a narrow range, instead of trying to comprehend the whole of the "world of small" within his survey; since he will find it much easier to acquire that guiding knowledge which already forms part of the fabric of physiological science, when the required amount of that knowledge is limited, instead of being voluminous; and his corrective experience will be much more speedily rendered precise and efficient, when it is constantly brought to bear on the same class of facts, than when it is only occasionally called into play through the too-wide range of his observations. I should be far, however, from recommending any one to limit himself *entirely* to a single department of microscopic study; on the contrary, the highest education of the eye, or rather, of the perceptive mind (for it is after all the mind that sees, and not the eye), can only be attained by a widely-extended course of observation. And every young microscopist, in first training himself in the knowledge of *what* to observe and *how* to observe, will do well to examine objects of the most varied kinds, and to learn as much about them as his time will permit. But it is when this preliminary education has been passed through, that I strongly urge the limitation of the attention to particular departments

of research, as the means by which alone, in this, as in every other branch of scientific inquiry, can any really good results be attained.

I hope that I shall not be supposed desirous of trumpeting the merits of my own production, if I say that in the 'Manual of the Microscope,' which I have just brought to a conclusion, I have especially aimed, on the one hand, to put the young microscopist in possession of what it is most essential that he should know at starting, on each of the most important topics to which his attention may be directed; and on the other, to point out how much remains to be known, and to guide him into the path of research which he may follow with the greatest likelihood of beneficial results. And I cannot point to a better example of the advantage to be derived from the steady devotion of the attention to a definite object, than is presented by the admirable contributions which have been made during the last year by Mr. Wenham, to two most important departments of vegetable physiology; especially by his memoir on Vegetable Cell Development, which appears in the last part of our Transactions (Jan. 1856). To this I shall presently have occasion to make particular reference; and I shall now only remark, that I look upon it as one of the most important rectifications which the current doctrines of this science have ever received; and that, although the product of one who must be considered an amateur rather than a professor of science, it would, in my opinion, do credit to the most accomplished physiologist. I should have hesitated, perhaps, at pinning my faith upon Mr. Wenham's statements, had it not been for two circumstances which have had a powerful influence with me: in the first place, the care in observing, and accuracy in recording, of which Mr. Wenham's previous paper on the 'Rotation of Sap in Vegetable-cells' gave satisfactory evidence; and secondly, the coincidence of the results of Mr. Wenham's researches and conclusions, with those towards which many recent inquiries on the history of cell-development seem to me to converge.

It is of great importance to the progress of any department of Science, that we should from time to time review the state of our knowledge on those fundamental questions which affect its condition and aspect; and it appears to me that the time is now come, when we must take such a review of the Cell-theory of Schleiden and Schwann, in its relation to Vegetable and Animal Physiology. To such a review I propose now to lead you: it must necessarily, from the briefness of the space at our command, be a very cursory one; but I venture to hope that I may succeed in so placing before you

the aspect under which the questions at issue present themselves to my own mind, as to lead you to a conception of the mode in which (as it appears to me) their solution is to be sought for. That I have myself fully attained that solution I dare not affirm. That the principle I offer to you, however, is more consistent with known facts, than are the doctrines commonly entertained, I feel a very strong conviction.

Although the general organization of Plants was so far understood at the time when Schleiden first came before the public, that every vegetable tissue was recognised as essentially *cellular* in its nature, yet I consider it to have been by him that the fundamental truth was first broadly enunciated, in 1837, that, as there are many among the lowest orders of plants in which a single cell constitutes the entire individual, each living *for* and *by* itself alone, so each of the cells, by the aggregation of which any individual among the higher plants is formed, has an independent life of its own, besides the 'incidental' life which it possesses as a part of the organism at large; and that the doctrine was first proclaimed, that *the life-history of the individual cell* is, therefore, the very first and absolutely-indispensable basis, not only for Vegetable Physiology, but (as was even then foreseen by his far reaching mental vision) for the science of life in general. The first problem which he set himself to investigate, therefore, was, *how does the cell itself originate?* It is unfortunate that he should have had recourse for its solution to some of those cases in which the investigation is attended with peculiar difficulty; and it is, doubtless, in great part to this cause, that we are to attribute certain fallacies in his results, of which subsequent researches have furnished the correction.

The publication of the 'Microscopical Researches' of Schwann, in 1839, marks a like era in Animal Physiology. For although the doctrine could not be said to be a new one, that each integral part of the animal body possesses an independent life of its own, in virtue of which it performs a series of actions peculiar to itself, provided that the conditions of these actions be supplied, yet it derived a new significance from the idea with which he connected it, that the integral parts are either *cells* or *derivatives from cells*, and that their independent life is, therefore, *cell-life*. This idea, avowedly suggested by that of Schleiden, was based by Schwann on the apparently-satisfactory results of his microscopic observations on the development of the animal tissues. For he found, that however diverse may be the structure and actions of the component parts of the animal organism in their fully-developed condition, there is a period in its

history when it is nothing else than an aggregation of cells, all apparently similar to each other; and as in some of the tissues—for example, in the blood-corpuscles, fat, cartilage, epidermis, epithelium, and the grey matter of the nervous centres—the cellular character is preserved throughout life, so might it be reasonably inferred that the rest are derived from cells, by a metamorphic process whose consecutive stages might be traced by microscopic observation. This was the problem which Schwann set himself to elucidate, and which he has been generally considered to have gone far to solve. For although an exception was early taken by various observers both on the continent and in this country, in regard to that simple fibrous tissue which is formed by the fibrillation of the effused blastema or organizable plasma of the blood, almost every microscopic observer, down to a very recent period, who has devoted himself to this department of inquiry, has taken Schwann's idea as his guide, and has considered it to be his main object to extend and complete it, by more fully elucidating the series of steps by which bone, tooth, shell, muscle, nerve, &c., are evolved from the cells in which they have have been almost unquestioningly believed to originate.

The doctrine of Schwann and his followers, however, has lately been the subject of very acute criticism on the part of Mr. Huxley; who has urged many arguments for the conclusion, that the cell is not the essential integer of the living organism which it has been, and still is, held to be by most physiologists; that it is only one out of many forms of organic structure, into which the organizable blastema may evolve itself; and that many animal tissues may form themselves directly out of this blastema, without undergoing the intermediate condition of cells.*

Although I am not by any means disposed to go as far as Mr. Huxley in abandoning the cell-doctrine of Schwann and his followers, yet I cannot but admit the correctness of much that he has urged. The essential truth, however, seems to me to lie between the two extremes; in other words, the cell-doctrine of Schwann can only be accepted when the word "cell" is understood in a sense much wider than that to which he limited it; but when it has been thus modified, there does not seem to me to be any adequate reason for relinquishing it. Fresh light having been thrown upon the subject by recent researches into the lowest types both of

* See his Memoir on the Cell-Doctrine, in the 'Brit. and For. Med.-Chir. Rev.,' vol. xii.; and his article, 'Tegumentary Organs,' in the 'Cyclop. of Anat. and Physiol.,' supplementary volume.

vegetable and animal life, I shall first proceed to inquire how far these researches tend to modify our idea of what constitutes a cell; and shall then test these modifications by the results of inquiries into the structure and development of more complex organisms.

The typical vegetable cell has commonly been considered to consist, externally, of the cellulose wall,—next to this, of the primordial utricle,—within this, of a layer of protoplasm, usually mingled with chlorophyll-granules,—and, finally, of the liquid cell-contents. But we find, among the simplest Protophytes, that all the functions of vegetative life are performed by beings which do not present any such differentiation of parts. Thus each individual of the *Palmoglæa macrococca* (Kutzing) seems to be a particle of viscid plasma containing green granules, having neither definite limitary membrane on its surface, nor definite cavity in its interior; and this is surrounded by an indefinite gelatinous envelope, which usually coalesces with that of other similar particles, so as to form a continuous slimy matrix. Now each of these particles has a nucleus like that of fully-developed cells; it increases by drawing into itself nutritive materials, which it converts into the organic compounds it requires for its augmentation; it undergoes duplicative subdivision, by which the single particle gives origin successively to two, four, eight, &c., after the ordinary method of multiplication of unicellular plants; and finally it conjugates with another like itself, the substance of the two particles being fused together in such a manner as to demonstrate the non-intervention of any limitary membrane, and the product being a "spore" or rather a "primordial cell," which originates a new generation by the renewal of the process of duplicative subdivision.

Now if we compare the life-history of this *Palmoglæa* with that of any unicellular plant that may be familiar to us,—one of the *Desmidiaceæ* for example,—we shall see that in all essential particulars it is the same; and that the only difference lies in the *less-developed* condition of the former as compared with the latter. For if its nearly homogeneous mass of protoplasm were to take upon itself that tendency to *differentiation* of its component parts, which operates in the production of the perfectly-developed vegetable cell, a very easy transition would speedily manifest itself from one condition to the other. For the surface of the protoplasm would gradually undergo condensation, so as at last to be converted into a more or less definite membrane, the "primordial utricle;" *

* It is maintained by some recent observers, that the "primordial utricle" of Mohl is not to be regarded as a proper membrane, because it is

at the same time, "vacuoles" filled with a more liquid material would appear in the substance of the protoplasm, and these would increase and coalesce, until at last the principal part of the interior would be occupied by the watery fluid, the viscid protoplasm being confined to the layer immediately lining the primordial utricle. Further, the secretion from the surface, instead of being a soft gelatinous slime, would constitute a firm protective envelope,—the cellulose wall. Now this is what may be actually seen, in following the evolution of the "zoospores" of Confervæ, &c., into perfect cells; for these zoospores are nothing else than protoplasmic particles, formed by the subdivision of the contents of the cell from which they are set free, having one or more filamentary prolongations, by the vibration of which they are propelled through the water; and it is not until they have fixed themselves, and have begun to grow, that they present any indication of that distinction of parts, which I have spoken of as characterizing the typical cell.

There is another phase in the lives, not only of Protophytes, but of more highly-organized plants, in which, according to recent observations, a most important functional act is performed by particles of protoplasm not yet furnished with a cell-wall. Thus in *Vaucheria*, in which the existence of distinct sexes, and the performance of a true generative act has been substantiated by the admirable observations of Pringsheim, it seems very clear that while the contents of the sperm-cell are metamorphosed into self-moving antherozoids which make their escape from it, those of the germ-cell simply form an aggregate spherical mass in its interior, which, at the time of the entrance of the antherozoids, has no limitary membrane. The antherozoids, coming into contact with its surface, swarm over it, and seem to undergo dissolution upon it; and it is not until a fusion has thus been accomplished between the contents of the sperm-cell and those of the germ-cell, that the product of this fusion becomes invested with a definite membrane, and is thus developed into a cell. The observations of Dr. F. Cohn upon the generation of *Sphæroplea annulina* are to precisely the same effect; and Dr. Pringsheim, carrying out more fully the observations of Thuret on the fertilization of

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simply the superficial layer of the protoplasm more condensed than that which it encloses. It does not appear to the Author that this constitutes a sufficient reason for recognizing it as a definite membrane, where it has a membranous consistence. And the controversy will be seen to be one of words rather than of things, when the presence or the absence of this membrane is viewed as a matter simply depending upon the degree of differentiation which the protoplasm may have undergone.

the Fuci, has ascertained that the same holds good in their case.

Thus, then, we are driven either to admit that the essential integers of the vegetable organism,—that which may not only maintain an independent existence, but may increase and multiply both by self-division and a true generative process,—is not (as we have hitherto supposed it to be) a cell; or we are constrained to modify our definition of a cell, so as to make it include bodies which do not possess the attributes that have been hitherto involved in this designation. Whichever we do, we should keep constantly in mind the relationship of the two objects. For the nucleated particle of protoplasm, although not *structurally* a cell, is a cell *physiologically*, possessing all its most important functional endowments; and although it may never develop itself into the type of a cell in a few of the lowest Protophytes, which pass the whole of their lives in this homogeneous condition, yet in by far the greater number this simpler state is but transitory, the homogeneous particle of protoplasm speedily differentiating itself into a true cell; so that although not a cell *actually*, it may be regarded as a cell *potentially*. Instead, therefore, of characterizing the simplest type of vegetable organisation as a cell, having a distinct membranous envelope and liquid contents, we should more correctly describe it as a nucleated particle of protoplasm, that may either remain in that low grade of incipient organisation of which a *homogeneousness* (approximating that of inorganic bodies) is the distinctive feature, or may make that first advance in organisation which consists in the *differentiation* of its substance into the more solid envelope and the more liquid interior, the cell-wall and the cell-contents.

Now it is in showing that a process essentially the same takes place in the first formation of new organs in the higher plants, that the great value and interest of Mr. Wenham's paper consist. It has usually been supposed that every leaf originates in the duplicative subdivision of a certain cell of the axis, and that its subsequent extension is due to the continuance of the like process of cell-multiplication. Mr. Wenham has shown, on the contrary, that (in certain cases, to say the least) the leaf originates in a layer of protoplasm, which is in the first instance homogeneous, but in which large vacuoles, disposed with a certain degree of regularity, soon make their appearance; these vacuoles become the cavities of the first cells, whilst the plasma between them, acquiring increased consistence, become the walls of these cells. Sometimes, when one of the first-formed vacuoles is unusually large, it is divided into two by the extension of a bridge of protoplasm across it;

on the other hand, if the plasmatic division between the vacuoles should be unusually broad, a new vacuole forms in its substance. Now this mode of cell-development I believe to be altogether a new fact to physiologists; and although Mr. Wenham's observation stands as yet unconfirmed, yet it accords so well, on the one hand, with the facts which I have stated with regard to the simpler Protophytes, and on the other, with appearances which I have myself observed in various animal structures, that I feel a strong couviction of its essential truth.

If, now, we direct our attention to the *Protozoa*, or simplest forms of animal life, with a view to inquire whether there be among them any phenomena of a parallel kind, we are at once struck with the strong resemblance which their condition bears to that of the humblest Protophytes. Taking the well-known *Actinophrys sol* as a typical example, we find that it consists of a nucleated particle of "sarcode" (the equivalent of the vegetable "protoplasm"), whose destitution of anything like limitary membrane is evidenced by its extraordinary power of extending itself into filaments, which, when they happen to meet each other, undergo a complete coalescence. Yet this nucleated particle behaves, in many respects, as a true cell. It draws nutrient material into its interior, applies it to the augmentation of its own substance, and multiplies itself by duplicative subdivision. It has been supposed even to perform the generative act by conjugation with other particles like itself; but recent observations upon *Actinophrys* and allied organisms, have rendered it very doubtful whether the fusion of two of these particles is a real conjugation; since no special product has been observed to result from it; and not only two, but several, individuals have been seen thus to coalesce together, the composite mass afterwards resolving itself again into isolated particles not apparently differing in any respect from the originals. What is the true meaning of this act, therefore, we are at present unable to affirm; but the fact, however we may interpret it, is in itself extremely significant, as affording an additional proof of the homogeneousness of the sarcode-body of the *Actinophrys*. I need scarcely stop to remark, that the same is true of the animal bodies of the *Foraminifera* generally; for these, in so far as we are acquainted with them, are nothing else than homogeneous particles of sarcode, extending themselves into pseudopodia, whose coalescence, when they happen to encounter one another, affords ample evidence of the non-existence of any limitary membrane. In *Amœba*, the distinction between cell-wall and cell-contents begins to show itself; the super-

ficial portion of the sarcode having decidedly more consistence than the interior; and the pseudopodia being much less freely extended. Still, however, the consistence of this external layer is not such as to present any obstacle to the reception of alimentary particles into the interior of the sarcode-body through any portion of its surface, or to interfere with the rejection of indigestible particles,—the temporary orifice, in either case, being at once closed by the coalescence of its edges; so that there is obviously no definite limitary membrane, notwithstanding that the liquidity of a large part of the interior substance allows a free movement of granular particles in every direction, as I observed many years ago. Thus, the *Amœba* seems to me to represent that condition of the vegetable cell, in which the primordial utricle is distinguishable as the external more condensed layer of the protoplasmic mass, but does not possess the distinctness of a proper membrane. A more advanced stage is seen in the curious *Gregarina*, which must be regarded as corresponding with the *Protozoa* in the simplicity of its organization, whilst it resembles the *Entozoa* in the peculiarity of its habitat. For here, the distinction between the cell-wall and the cell-contents is decidedly marked; the former becoming more consistent, and the latter more liquid. The body undergoes great changes of form, but no pseudopodial extensions are sent forth; and the nutrient materials being imbibed in a liquid state by the whole surface, neither are solid particles introduced by an oral orifice extemporised in the superficial layer, nor are rejectamenta extruded through a like extemporised anus. Passing-on to the *Infusoria*, we find much reason to regard these simpler forms (at any rate) in the light of cells modified for an independent existence; and their essential difference from *Actinophrys* and *Amœba* seems to lie in this, that the external layer of the sarcode is condensed into a more definite limitary membrane,—a change which involves other alterations. For, in the first place, the body can undergo comparatively little change of form; and no pseudopodia can be sent forth. And, secondly, as the alimentary particles can no longer be introduced through any point of the surface, a definite orifice is left in the membranous envelope, into which the nutrient materials are driven by the peculiar disposition of the cilia; and, in many cases, a definite anal orifice is also provided, through which indigestible matters may be ejected.

Thus, among the *Protozoa*, as among the *Protophyta*, whilst we trace a gradual advance in the differentiation of the homogeneous particle of sarcode into the true cell, we find vast

multitudes of beings passing their whole lives (so far, at least, as we are acquainted with them) in that earlier and simpler condition, in which no such differentiation has taken place, and in which, therefore, the structural constitution of a cell has not been attained.

Now before I pass on to inquire how far this condition finds its parallel in the elementary parts of higher organisms, I wish to stop for a moment, to notice how strongly the differences between the Vegetable and Animal kingdoms are marked out, even in those lowest and simplest forms of both, which we have been just engaged in considering. For the *Protophytes*, like the most perfect Plants, draw their nutriment from the inorganic compounds which are everywhere within their reach,—water, carbonic acid, and ammonia; by decomposing carbonic acid, they give off oxygen; and they form for themselves the starch and the chlorophyll, the cellulose and the albumen, which they apply to the augmentation of their own substance. On the other hand, even those humblest *Protozoa*, the *Rhizopoda*, can only exist (so far as we can see) upon organic materials previously elaborated by other beings: these they receive "bodily" into their interior; and though mouth, stomach, intestine, and anus, all have to be extemporized every time that the animal feeds, yet the digestion which the alimentary particles undergo in its interior, is not less complete than that which is performed by the most elaborate apparatus which we anywhere meet with; and the nutrient materials thus obtained seem to be appropriated, without any further conversion, to the augmentation of the substance of the body. Thus, notwithstanding the remarkable *analogy* which these two orders of beings exhibit, I cannot see that any difficulty need be experienced in separating them, when we are acquainted with their mode of nutrition. The *Gregarina* constitutes no real exception; for although it imbibes its nutriment through its entire surface, like the *Protophyte*, yet that nutriment has been previously digested and prepared for it by the animal whose body it inhabits; and in the absence of any oral orifice or digestive apparatus of its own, it corresponds with a far higher group of animals, the Cestoid Worms, which live under the same conditions. Some recent observations, it is true, would seem to invalidate this distinction, by showing that certain rhizopods and infusoria have their origin in undoubted plants; but we must be permitted for the present to withhold our assent from conclusions so strange, and to question whether they may not be invalidated by some unsuspected fallacy. It has been well remarked, however, that "there is no limit to the possibilities

of Nature;" and I should be the last to attempt to set up as fixed laws what are merely the expressions of the present state of our knowledge, or to wish to throw discredit on the observations of accomplished and careful microscopists, merely because they overthrow distinctions which I had imagined to be well founded. I would strongly recommend the observations of Professor Hartig (Quart. Journ. of Microsc. Science, Vol. IV., p. 51) and of Mr. Carter (Ann. of Nat. Hist., Feb., 1856) to your attentive scrutiny; and hope that some of our members may be able, ere long, to furnish either a confirmation or a refutation of them.

Turning, now, to some of those parts of the fabric of higher animals, in which a cellular organization has been described by some observers and denied by others, I think I shall be able to show that the discrepancy is capable of being reconciled, by the application of the principle of progressive differentiation to the mass of sarcode in which any such organ originates. Thus having found, in various kinds of shells, certain instances in which a very definite cellular organization appeared to me to exist,—others in which this organization was less definite, though still (as I thought) unmistakeably present,—others in which it was only faintly indicated,—and others in which I could discern no traces of it;—and having also met with gradations from one condition to another, even in the very same shells;—I thought myself justified in concluding that the animal basis of the shell-substance must have been originally cellular in every case, but that the divisions between the cells must have been lost in some cases by a very early coalescence. Mr. Huxley, on the other hand, has recently expressed an opinion,* founded on an examination of my own preparations, that the whole of my interpretation is erroneous, and that no cellular structure can really be discerned in shell. Now in the justice of this verdict, I cannot say that I am prepared to coincide; on the other hand, I am quite ready to admit that my original interpretation requires modification. Taking the general history of the first formation of a leaf from a layer of protoplasm, as probably applicable to the formation of a lamina of shell from a layer of sarcode, I should now interpret the appearances which my preparations exhibit, as follows:—In those forms of shell-substance in which I can discern no structure whatever, and in which a continuous membrane is left after decalcification, I should be disposed to think that the entire layer of sarcode has undergone calcification, before any differentiation of parts had begun to take place in it. In those again in which (as in *Mya* and *Thracia*) a

* 'Cyclopædia of Anat. and Physiol.,' Supplement, p. 489.

cellular arrangement is more or less obvious in the section, but in which no distinctly-cellular residuum is left after decalcification, I should infer that the processes of vacuolation and of consolidation had commenced, but had not proceeded far, when the calcification took place. Lastly, in those in which (as in *Pinna*) a very definite residuum, apparently cellular, is left after decalcification, the very striking resemblance which this bears to that stage in the vacuolation and consolidation of a layer of protoplasm about to form a leaf (as described and figured by Mr. Wenham) which immediately precedes the formation of distinct cells, induces me to think that such must have been the stage in which the sarcode-layer must have undergone calcification. Hence, whilst agreeing with Mr. Huxley that in few (or perhaps none) of the structures which I have described as cellular, are any complete cells ordinarily formed, I still believe that in all of them there has been a *nisus* more or less operative, towards the development of cells; their differences lying solely in the greater or less degree of differentiation, *tending towards* the production of perfected cells, which had manifested itself in the sarcode at the time of its calcification.

I am strongly disposed to believe, that the same doctrine will apply to many other animal structures, in which the presence of a cellular organization is affirmed by some and denied by others. If, for example, you look at the scale of an *Eel*, you observe that its otherwise homogeneous substance is marked out by ovoidal spaces, which suggest the idea of cartilage-cells with an intervening matrix. By Professor Williamson, who has carefully studied the structure of fish-scales, a layer of this kind has been shown to be of very general occurrence; and he considers these ovoidal spaces to be "botryoidal concretions" of calcareous matter, having no relation whatever to cells. And he puts the like interpretation on analogous appearances exhibited by various egg-shells, which have been regarded by Professor Quekett and others as indicative of a cellular organization. Now the microscopic appearance of the scale of the Eel so precisely resembles that of the leaf-forming layer of protoplasm, as figured by Mr. Wenham, that I can scarcely doubt that its ovoidal spaces are vacuoles formed with a view (as it were) of becoming cells; and that the regularity of the shape and disposition of the calcareous concretions is determined by that of the vacuolations. And the condition of such egg-shells as exhibit an appearance of cellular structure, so closely resembles that of many shells of mollusks, in which there is a cellular areolation without well-

defined membranous partitions, that I can scarcely hesitate in attributing to it a similar origin.

The general doctrine, then, which seems to me best to express the facts I have stated, is that those essential endowments which we have been accustomed to attribute only to the typical cell, may exist in that comparatively-homogeneous substance which is commonly termed "protoplasm" in the vegetable kingdom, and "sarcode" in the animal; that isolated particles of this substance may comport themselves after the manner of true cells, although no distinction between cell-wall and cell-contents may have made itself apparent; and that various organs and tissues among the higher plants and animals have their origin in larger extensions of the same substance, in which the process of *cellulation* may either proceed to the complete evolution of an aggregate of perfect cells, or may be stopped at any point, so as to leave but faint traces of the tendency in question. I have already adverted to the belief which I have from the first entertained, that in the animal body, the *fibrillation* of the blastema may take place quite independently of cellulation; and I am much disposed to think that the formation of other tissues may take place by a like direct process of conversion. But I wish to take this opportunity of protesting against the assertion, that where no perfected cells can be demonstrated, there is not a tendency to a cellular organization, however incomplete may be its result. It would be just as unphilosophical, in my opinion, to assert that the white fibrous tissue does not manifest the tendency of the blastema to fibrillate, because it seldom exhibits isolated sharply-defined fibres like those of the yellow or elastic tissue.

Some apology might, perhaps, seem due for thus occupying your time in an abstract physiological disquisition; but next to correct observation, is the right interpretation of what we see; and, in fact, it is often extremely difficult (as is obvious in the history of this very inquiry) to distinguish between the impressions which the objects themselves make upon our minds, and the ideas which we connect with those impressions. And I am desirous that those whom I have now the pleasure of addressing, should be put in the way of examining for themselves into the merits (1) of the cell-doctrine as commonly held, (2) of the opposite view put forward by Mr. Huxley, and (3) of the intermediate doctrine which I have this evening endeavoured to expound.

It now only remains for me, in resigning the chair to my successor, to thank you most gratefully for the kind indulgence which you have so constantly extended to me; and to express my regret that I have not been able to do more to promote the interests of the Society, by myself furnishing original communications to its meetings. It is known to many of you, that the small amount of time which I can spare for original research, has long been devoted to one special object, the elucidation of the structure and physiology of the *Foraminifera;* and the liberal assistance which has been afforded me by the Royal Society in the prosecution of my researches (whereby I have been enabled to procure the unrivalled series of microscopic drawings that I have exhibited from time to time at our meetings), makes me feel it but common gratitude, to place before that Society the systematic results of my researches. And further, the number and variety of demands upon my time have entirely precluded my making any such active exertions to obtain communications from others, as may not unreasonably be expected from your President. I have the gratification of believing that my successor may be much more able than I have been, to contribute to your welfare in both these modes; and it is, therefore, with much satisfaction that I look forward to being replaced by one of the oldest members of the Society, who has given evidence of such extensive attainments in various departments of Microscopical Science, and who will, I feel confident, do the fullest credit to your choice. I have only to beg you to believe, that the warmest desire to promote the interests of the Society has never been wanting on my part, and that nothing but the coercion of circumstances, which I could not control or resist, has prevented me from more fully manifesting the sincerity of that desire in labour for your benefit.

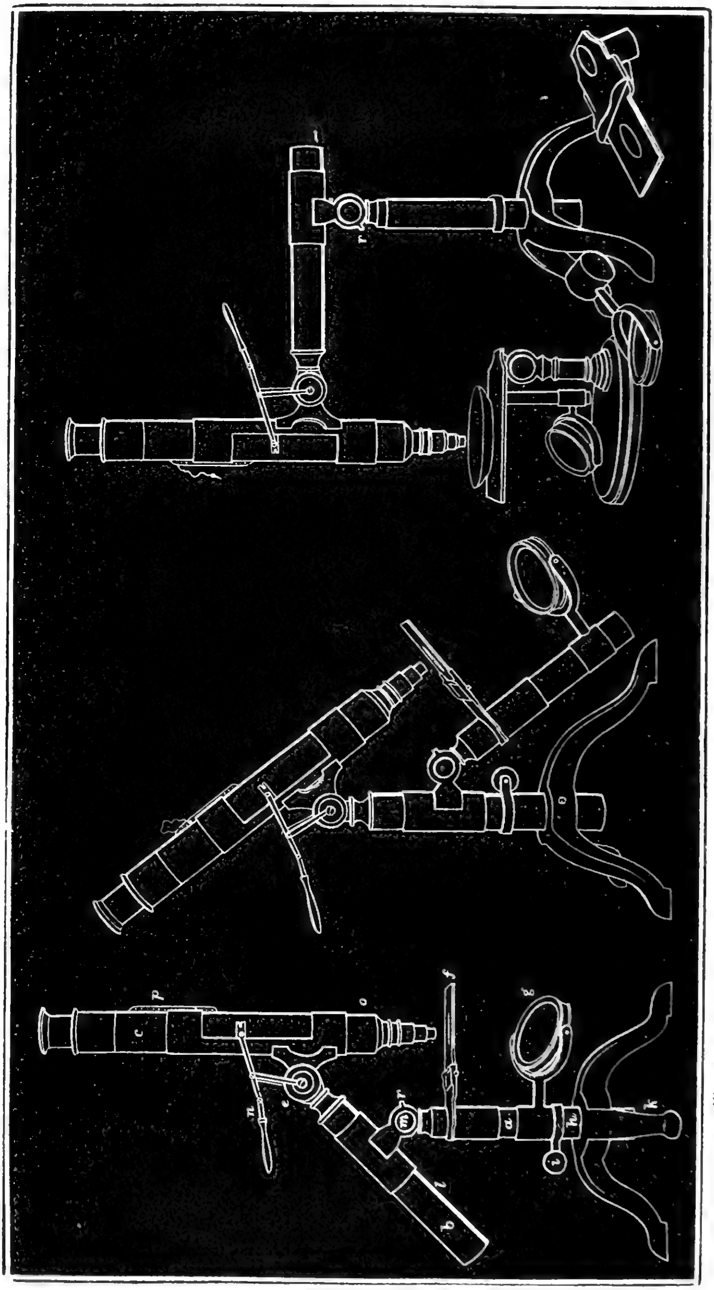


Fig. 1.

Fig. 2.

Fig. 3.

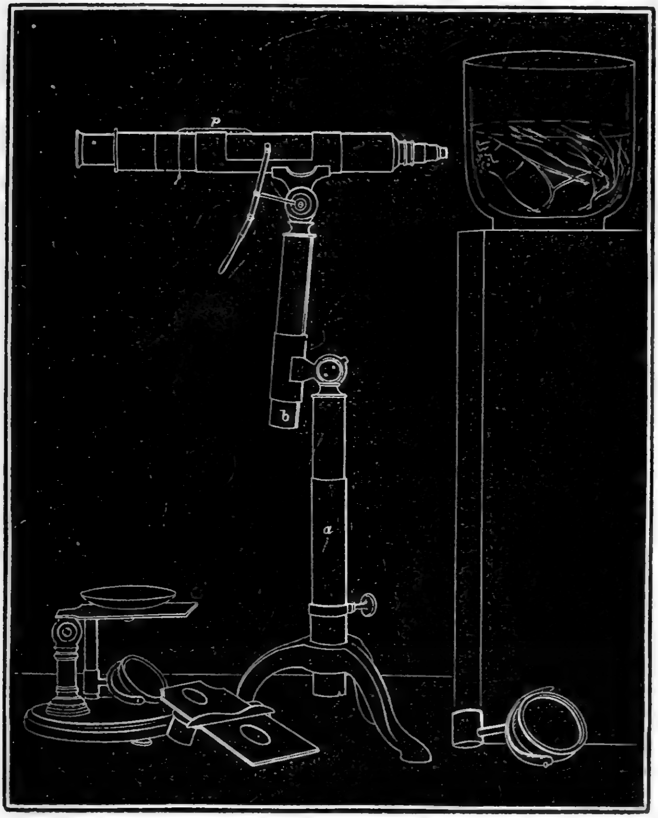


Fig. 4.

On the Post-tertiary Diatomaceous Sand *of* Glenshira. Part II. *Containing an account of a number of additional undescribed species.* By William Gregory, M.D.,F.R.S.E., M.R.I.A., &c.; Professor of Chemistry in the University of Edinburgh. Illustrated by numerous figures drawn from Nature, by R. K. Greville, LL.D., F R.S.E., &c., and engraved by Tuffen West, Esq. (Plate V.)

(Read March 26, 1856.)

In the first part of this communication * I described the peculiar locality in which the Glenshira Sand occurs, and pointed out, that the remarkable mixture of marine and fresh water forms which it contains, was a proof that, when this sand or mud was deposited, the fresh-water lake, then filling the upper part of the valley, and standing, of course, at a higher level than it now does, must yet have occupied the same relative level, compared with the sea, which it now occupies, when it is confined to the lowest part of the valley, and being exactly at the level of half-tide, flows into the sea at low water; while, at high water, the sea flows into the lake. This state of matter produces in the lake, at this moment, a mixture of marine and fresh-water species, not only of diatoms, but also of other tribes, both animal and vegetable. And as the existence of a similar mixture in the sand now under examination, deposited at the higher level, implies that at the period of its deposition the relative levels of the sea and of the lake were the same as now, while we see that the lake now stands at a lower level than formerly, we infer, that since that period the land has risen, or the sea has fallen; a conclusion justified and supported by many other geological phenomena in the estuary of the Clyde, with which Loch Fine, the arm of the sea into which the Dhu Loch of Glenshira flows, communicates.

In the same paper I gave a list of about 215 known species of Diatoms, and nearly 20 undescribed species, which I had found in the deposit; a number of species far exceeding that hitherto found in any other similar deposit, so far as is known to me. This, I conceive, indicates that the circumstances which favoured the mixture and accumulation of species must have been of very prolonged duration.

At the same time I stated that there remained about as many more undescribed forms as those I had been able at that time to figure, and that these should be figured and described on some later occasion. I now proceed to fulfil that promise. I must explain, however, that it is impossible for me to com-

* 'Quarterly Journal of Microscopical Science,' vol. iii., p. 30.

plete the investigation in the present paper. In the first place, the sand is not yet exhausted; for although I have explored about 600 slides of it, new forms are still from time to time occurring. Secondly, it has been found impossible to finish the study even of the whole of those which I had observed in it in 1854, and to prepare figures of them. I propose, therefore, only to describe and figure, at this time, such of the new forms as have been duly studied. This is, no doubt, the majority of them; but it will require a third paper to complete the examination, more especially of the smaller forms, among which, as well as among those of the larger which have not yet occurred entire, much remains to be done.

Before describing the new forms, I must add to the list of known species formerly given the following, many of which were accidentally omitted. Others have since occurred to me, and a few have been pointed out to me by Mr. Okeden, well known as a zealous observer. These I have also myself seen.

Additional List of known Species.

235.* Cymbella sinuata, W. G.
236. Amphora membranacea.
237. „ salina.
238. „ hyalina.
239. Amphiprora paludosa.
240. Campylodiscus Ralfsii.
241. Actinocyclus undulatus.
242. Actinocyclus ?
243. Actinocyclus duodenarius, Sm.
244. Nitzschia bilobata.
245. Navicula Westii.
246. „ obtusa.
247. „ Hennedii.
248. „ rostrata.
249. Navicula varians, W. G. (in all its forms).
250. Navicula Pandura, Bréb. (?)
251. Pinnularia megaloptera, Ehr.
252. „ biceps, W. G.
253. „ linearis, W. G.
254. „ subcapitata, W. G.
255. „ gracillima, W. G.
256. Pleurosigma distortum.
257. „ intermedium.
258. Gomphonema subtile, Ehr.
259. Orthosira spinosa.
260. „ mirabilis.
261. Grammatophora Balfouriana.† (See Synopsis, Vol. II. Pl. LXI. fig. 383.)

On this list I would only remark, that the species marked W. G. have been lately described by me, as well as Nos. 248, 251, and 258, the two last as new to Britain;‡ that No. 249, *Navicula varians*, has been also fully described by me elsewhere:§ that No. 243, *Actinocyclus duodenarius*, appears

* These numbers are continued from Part I., in which I gave a list of 234 species.

† I have given a figure of this form, as being little known as yet. At first it seemed to differ from the form figured by Dr. Greville, the interrupted vittæ being less conspicuous, the striæ more so; but I am now satisfied that it is essentially the same form, which varies, however, more than was at first supposed. The figure is not numbered, as it is not intended for engraving.

‡ 'Quarterly Journal of Microscopical Science,' vol. iv., p. 1.

§ 'Trans. Micr. Soc., Quart. Journ. of Micr. Science,' No. X., p. 10, Jan. 1855.

as a British form in Vol. II. of Smith's Synopsis. I have found in Glenshira several forms of this kind, differing only in the number of septa, which varies from 7 or 8 to 14 or 16. I observe in Pritchard's Animalcules, that Ehrenberg makes a species of each number of septa; but to judge by the aspect of these forms in Glenshira, they are all of one species, which I have named *duodenarius*, because 12 is about the average of the septa in those I have seen there. No. 250, *Navicula Pandura*, was last year figured by De Brébisson as occurring at Cherbourg. I mark it with a query, because it is doubtful whether it may not be the same species as *N. nitida*, Sm., (named in my former list,) and also because I have great doubts as to either of these forms being correctly named. They belong to a very striking group, in which the Glenshira sand is somewhat rich, and which I shall have presently to consider more fully.

Of No. 247, *Navicula Hennedii*, I give a figure, because very fine specimens occur in this deposit, and the form has not yet been figured, though it will be described in Vol. II. of Professor Smith's Synopsis. The two *Orthosiræ* are also new forms; *O. spinosa* having been found in Braemar by Drs. Greville and Balfour, and in Auvergne by Professor Smith, and figured both by Dr. Greville and Professor Smith; and *O. mirabilis* having been found last summer in Wales by Mr. Okeden, but not yet figured. I may here mention, that I had observed and sketched both, in my earliest explorations of the Glenshira sand, fully three years ago; but from the number of new forms, I was compelled to postpone the study of them, and had not been able to resume it when the naturalists above named discovered them. But before the account of *O. spinosa* had appeared, I had again found both forms in three or four South American soils. I mention this here, because my observations on these soils have led me to doubt whether *O. mirabilis* be not an abnormal state of *O. spinosa*.

My reasons for thinking so are: 1. That in all the localities in which *O. mirabilis* occurs, it is accompanied by *O. spinosa*. 2. In the Glenshira sand and in the American soils, I was unable to find any discoid or end view, or diaphragm, which I could suppose to be that of *O. mirabilis*, except that of *O. spinosa;* and I believe that Mr. Okeden has been equally unsuccessful. 3. I found one cylinder, one-half of which had the peculiar markings of *O. mirabilis*, namely, two series of curved or sigmoid lines, decussating and crossing the cylinder transversely; while the other half had all the characters of *O. spinosa*. 4. In no specimen of *O. mirabilis* have I seen any appearance of the usual septa, so strongly marked in

O. spinosa, which leads me to suppose that the markings are due to the septa having been removed and replaced by some new internal arrangement. 5. In both forms, the ends of the cylinders exhibit the spines, or appearance of spines, from which *O. spinosa* is named. It was for these reasons that I did not earlier mention *O. mirabilis* as a species; and as for *O. spinosa*, I had postponed it with other forms, otherwise both might long ago have been known.

Let us now turn to the new forms. Here I must premise that a few of those new figures were described and figured in my former paper. I have figured these again, in some cases, because the former figures were accidentally erroneous; or in others, on account of additional peculiarities, or because I now understand the forms better than I was at that time able to do. By far the greater part of the forms now given are figured for the first time.

1. *Navicula rhombica*, n. sp. In my former paper are two figures of this species, which is very frequent in the sand. I now give two more figures, to complete the history of it.

Length from 0·001″ to 0·0025″. Form rhombic, with somewhat acute apices as in the former figures, or elliptic lanceolate, with obtuse extremities, as in fig. 1. Striæ fine, but easily seen with a good 1-4 or 1-5, about 45 in ·001″, but those near the middle of the valve much more distant, so as to be almost conspicuous; the striæ slightly inclined. Median line strong; nodule large and well marked. Valve colourless, or pale yellow.

The above characters sufficiently distinguish this species from *N. rhomboides*, which, in the typical form, is always acutely rhombic, of a much darker colour, and has no definite central nodule, the two halves of the median line ending in sharp triangular points. The striæ in *N. rhomboides* are so fine, that I have never yet been able to see them with a 1-5 of extraordinary goodness, and they are indeed hardly to be resolved by the 1-8; they are also parallel. All these things unite to give to *N. rhombica* an aspect so entirely different from that of *N. rhomboides*, that it is impossible to confound the two forms, where, as in the present deposit, they occur together. I may add that the variations of *N. rhomboides*, viz., *N. crassinervia* and *N. interrupta*, W. G., are quite distinct from those of *N. rhombica*. I state this, because some who have only seen the figures of *N. rhombica* in my former paper, have supposed that it is only *N. rhomboides*. Those who have seen the forms will admit that it is not possible for two species of the same genus to differ more thoroughly; but it is im-

possible, in all cases, to represent in drawing, characters which, in the forms, are perfectly satisfactory.

Since writing the former paper, however, I have observed an additional mark of distinction, which has even led me to doubt whether the form under consideration be a *Navicula* at all; for it frequently occurs in what I may call packs, like packs of cards, in which six, eight, or more are laid flat and close on each other. I have represented one of these in fig. 1.* This is a character which I have not observed in any *Navicula*, although it is easy to imagine that some species of the genus may occur in such groups. From the fact of these packs being so frequent in a deposit like this, so long water-tossed, it may be inferred, that the forms composing them are very firmly attached together in the living state. I must leave to better authorities to decide whether this be a *Navicula* or not, merely observing that it is a well-marked and beautiful species.

I believe *N. rhombica* to be a marine form, having seen it, with other marine species, in a recent gathering from the coast near Tantallan, Haddingtonshire. There were also some fresh-water, or rather brackish-water forms, derived from the mouth of a small brook near the spot. If it be marine, this will be another point of distinction between it and *N. rhomboides*. I have seen no trace of it in all the very numerous fresh-water gatherings I have studied, though *N. rhomboides* is one of the commonest forms (222.)†

2. *Navicula maxima*, n. sp. This was also figured in my former paper, but I now give some additional figures of it, both because I have since found much finer specimens, and in order to show its usual varieties.

Form linear, broad, usually a little incurved at the middle, with broadly acuminate apices, as in fig. 2. Also linear, narrow and long, without constriction, as in fig. 2*. Some of this variety are very long and narrow; and there are also forms intermediate between 2 and 2*, as in fig. 2**. Length from 0·0035″ to 0·0065″. Median line strong, usually somewhat bent towards the central nodule, at least in the broader variety. Striæ transverse, parallel, reaching the median line; fine and close, about 50 in 0·001″ in the broader, considerably finer in the narrower variety. Colour of the valve in balsam, clear straw yellow. The valve is thick and convex, so that, when not lying quite flat, the edges become black. It is a very striking form, and frequent in the coarser densities of the prepared sand.

From the figure formerly given, some have supposed it to be identical with *N. firma* β, Sm. As that form was not

† This is the number attached to the species in the list given in Part I.

figured in the Synopsis, Vol. I., and I was at the time little acquainted with it, I was at first inclined to adopt this view. But a further examination of both forms has satisfied me that they are distinct. *N. firma* β has, even in balsam, a strong brown colour; its striation is coarser, and far more conspicuous, and is also slightly inclined; and it forms several well-marked varieties, which have been described and figured by Ehrenberg as distinct species, such as *N. dilatata*, *N. amphigomphus*, and others. Now, so far as I can see, *N. maxima* exhibits no other varieties than those here figured, which I give for the purpose of comparison. Moreover, while in *N. firma*, in all its forms, we have a side line on each side of the median line, *N. maxima* has usually two such lines on each side. Lastly, both forms occur in this deposit, and are easily distinguished by their general aspect, even under a low power. (225.)*

3. *Navicula Hennedii*, Sm. I give a figure of this beautiful species, because no figure of it has yet been published, and because the finest specimens I have seen occur in the Glenshira sand. As it will be fully described in the Synopsis, Vol. II., I need only say here, that fig. 3 represents a very fine one, although I have a specimen one-half larger even than this. (247.)†

4. *Navicula latissima*, n. sp. This is another very fine species, which occurs very well developed in our deposit.

Form very broadly elliptical, with very obtusely acuminate apices, having usually a very slight constriction before the extremities. The sides are occasionally parallel in the middle. Length from 0·002″ to 0·005″, or even 0·006″. Some of the shorter individuals, from the great breadth, are nearly orbicular. Nodule very large, median line doubly conical, the bases of the cones meeting at the nodule. This appearance is due to the striation, which does not reach the middle, and recedes farthest from it near the central nodule. Striæ rather coarse, finely moniliform, highly radiate, and not reaching the true inner median line. Colour of the valve, in balsam, a strong straw yellow, occasionally light brown.

I understand that some are disposed to refer this form to *N. granulata*, Bréb., which, as I stated in my former paper, also occurs here. But I cannot do this; for in *N. granulata*, not only are the striæ much less numerous, even though it is a considerably smaller form, but they are composed of large granules, so distant as to give a special character, from which the name is taken. In *N. latissima*, the striæ are indeed

* So numbered in Part I.

† So numbered in the list of known forms, given at page 34.

moniliform, as in many other naviculæ, but this character is far from being conspicuous. Moreover, the invariable and decided colour of the valve distinguishes it from *N. granulata*, which is colourless. Neither have I ever seen in *N. latissima* the produced or apiculate apices of *N. granulata*. I consider *N. latissima* to have very well marked characters, and the aspect of the larger individuals to be entirely peculiar.

Fig. 4 represents one of the shorter, and fig. 4* one of the longer forms of this fine species. (262.)

5. *Navicula quadrata*, n. sp. (= *N. humerosa*, Bréb.) This form is allied to the preceding, and is equally frequent in the deposit.

Form rectangular or nearly square, the ends suddenly contracted to short produced apices. Length from 0·0015″ to 0·005″ or even more, the breadth not increasing with the length in the longer individuals. The usual length is about 0·0025″ or 0·003″. Striæ radiate, much finer than in *N. latissima*, minutely moniliform, coming nearer to the median line. Fig. 5 represents an example rather below the average size.

When I first observed this form, and sent it to de Brébisson, he told me that he had then just found it at Falaise, and had named it *N. humerosa;* but he preferred my name as having been the earlier, and as more characteristic. Subsequently, Professor Smith referred it to *N. granulata*, Bréb., with which it agrees in form, while it differs from it remarkably in striation and aspect. De Brébisson, having found it quite unmixed with *N. granulata*, still, I believe, regards it as a distinct species.* For this reason, I give it here as such, adding, however, that I think it probable that it may prove to be a variety, not indeed of *N. granulala*, but of *N. latissima*, from which it differs, indeed, both in form and in number of striæ, but which it resembles considerably in general aspect. In my paper on *Navicula varians*,† I have shown that neither outline nor number of striæ are to be relied on, in certain cases, as specific characters, and I shall take an early opportunity of directing attention to other facts of the same kind which I have since observed. I may add that in this deposit there occur forms which, both as regards outline and striation, are intermediate between this one and the preceding, *N. latissima*. Even as a variety, however, it requires to be noticed and figured, in order to give a correct idea of the species as we find it. (263.)

I may here state that all the three forms, *N. latissima*,

* It appears as such, I find, in Vol. II. of the Synopsis, p. 93, as *N. humerosa*. Of course I shall withdraw my name, and adopt that of de Brébisson, to avoid confusion.

† 'Quart. Journ. of Micr. Science,' No. X., p. 10, Jan. 1855.

N. quadrata, and *N. granulata*, are marine forms, and that they all occur in recent gatherings on our coasts.

6. *Navicula formosa*, n. sp. This is a very beautiful form, and is frequent in the coarser densities of the deposit.

Form, an elegant linear elliptic, or elliptic lanceolate, with somewhat obtuse extremities. Nodules large and definite; median line like that of many *Pinnulariæ*, such as *P. viridis*. Striæ slightly inclined, about 35 in ·001″, not reaching the median line. There is, on each side of the median line, a side line, parallel to it. Length from 0·003″ to 0·0065.″ At one time I referred *N. maxima* β and this form to one species, but in *N. formosa* the striæ, besides being inclined, and not reaching the median line, are much more conspicuous, giving to the form a peculiar and well-marked aspect. I had also some doubts, whether it should not be referred to *Pinnularia*, rather than *Navicula*, but I have preferred the latter, because I believe the striæ to be moniliform, though very minutely so.

Fig. 6 represents a specimen, nearly of the average size; it is, however, often considerably longer. I have not yet seen it elsewhere. (264.)

7. *Navicula pulchra*, n. sp. This very pretty form is not so frequent in the deposit as most of the preceding species.

Form, elliptic lanceolate, almost rhombic, with a slight inflexion towards the extremities; not very broad. Length about 0·003.″ Striæ not very fine, very highly radiate, and very strongly moniliform, which gives to it a very peculiar aspect. Fig. 7 represents what appears to be the typical form, which I have only seen in this deposit. (265.)

8. *Navicula angulosa*, n. sp. This very beautiful form is frequent in the medium densities of the sand.

Form elliptic lanceolate, rather broad, with acute apices. Length from 0·0025″ to 0·0045.″ Striæ conspicuous, marginal, and bounded, internally, by an angular, rhombic space. Nodules definite, median line sharp and distinct. It is represented of the average size in fig. 8. I understand from Mr. Bleakley, that he has found this form on our eastern coasts.

Var. β. Rather smaller. Form linear, sides parallel, ends acuminate, striæ more distant; otherwise agreeing with α. Represented in fig. 8*. This also seems to have occurred to Mr. Bleakley.

Perhaps this species ought to be referred to the genus *Pinnularia*, but it is not easy to define these two genera. We shall see presently that moniliform or costate striæ are not always to be depended on, although Professor Smith distinguishes them by these characters. I was at one time persuaded to refer this form to *N. palpebralis*, but having carefully studied authentic specimens of that species, I am satisfied that

they are distinct. Indeed *N. palpebralis* is a very small form, while *N. angulosa* is generally large and conspicuous. But the angular space in the middle in both varieties of *N. angulosa*, is a good and permanent mark of distinction. (266.)

9. *Navicula Macula*, n. sp. This is a very remarkable form, which is not rare in the lighter densities of the deposit; but I have never seen it elsewhere as yet.

Form elliptic in the middle, short, contracted, and again slightly expanding to very obtuse, almost truncate apices. In shape it is not unlike the larger specimens of *Cocconeis flexella* (*Thwaitesii*, Sm.). Length, 0·0015″ to 0·002″. Median line straight, abruptly terminating at two points some way on each side of the centre. There is no central nodule, but only a large blank space, the length of which lies across the middle of the valve, and which looks like a stain. Beyond this, towards each end, the valve is very finely striated. Striæ about 70 in 0·001″, transverse and parallel.

The peculiar blank central space, which is not at all like an expanded nodule, differs from anything I have seen in any other form. I have examined not less than 100 specimens, and in none of them could I see any appearance of a central nodule, nor could I trace the median line farther than the margin of the blank, as we can do in so many forms where the nodule is expanded.

Fig. 9 is a very accurate representation of this form, which is remarkably uniform in its characters. (267.)

10. *Navicula solaris*, n. sp. This is a very pretty and well-marked form, frequent in the middle densities of the deposit. It is represented in fig. 10.

Form rhombic, long and narrow, with obtuse extremities. Length from 0·0015″ to 0·0045″. The striation is fine, but very distinct, even conspicuous, very much inclined towards the ends, and in the centre, where there is a small circular blank spot, so highly radiate as to present the appearance of a sun with rays. Striæ 36 in ·001″. The valve is usually of a brown colour, more or less deep, even in balsam. There is some resemblance between the shorter individuals and *P. radiosa*; but *N. solaris*, besides having finer striæ, and those more inclined, is usually much longer. As both forms occur in the deposit, they are easily seen to differ very materially in aspect. I have not yet observed it elsewhere. (268.)

11. *Navicula Pandura*, Bréb.? In the course of last year a very beautiful form was described and figured under this name by de Brébisson as occurring in sea water at Falaise. I have here given under this name, as a British form, that which is represented in fig. 11, although it does not appear to be in all points identical with that of de Brébisson. But the Glen-

shira sand is particularly remarkable for the occurrence in it of several different forms of the same general type, which I figure that they may be compared with others from different localities.

That which I have named, doubtfully, *N. Pandura*, is in shape panduriform, very deeply constricted in the middle, with the extremities nearly triangular, broad, with somewhat acute apices. Nodule square; median line strong, double, straight, with two dark lines, parallel to it, and close to it on each side, converging at the ends. These lines are shades, caused by elevations in the striæ, and similar to those in *N. elliptica*, Kutz (*ovalis*, Sm.), and in *N. didyma*. Length 0·004″ to 0·005″. Striæ coarse, very conspicuous, costate. Indeed, had not de Brébisson named his form *Navicula*, I should have called it *Pinnularia*, as the costæ resemble those of *P. alpina*. It will be seen that the next form has the same character. (269.)

12. *Navicula nitida*, Sm.? I have named this form, represented in fig. 12, also doubtfully, as no description of the species has yet appeared. It is represented in fig. 12. Form like that of the preceding, but less deeply constricted, and the ends longer in proportion. Length 0·003″ or 0·004″. Striæ not quite so coarse as in the last, costate. I have been repeatedly informed that this is Professor Smith's *N. nitida*, but I cannot reconcile this with his definition of *Navicula* as having moniliform, *Pinnularia* as having costate striæ. (270.)

13. *Navicula incurvata*, n. sp. This form, which belongs to the same group, is a true *Navicula*, if that generic name imply moniliform striation.

Form approaching to that of the two preceding species, but much more gently constricted, narrower in proportion, and with the extremities very uniformly rounded. Median line straight, with the dark-shaded lines on each side. Striæ much finer than in the two last, about 30 in ·001″, and minutely moniliform. It is perfectly uniform in its character, and a well-marked species. Length 0·003″ to 0·004″. (271.)

14. *Navicula splendida*, n. sp. This very fine species is also a true *Navicula*, but still belongs to the same group.

Form panduriform, much constricted, very broad at the shoulders, ends triangular and obtuse. Length 0·005″ to 0·006.″ Median line straight, nodule square. Striæ rather fine, compared with the two first forms of the group; but distinctly moniliform; not reaching the median line, and leaving on each side of it a long narrow blank space, which adds to its apparent breadth. The aspect of this form, as may be seen in the figures, is very different from that of the other forms of the group. It is the rarest of them in this deposit, and, as yet, has not occurred elsewhere. (272.)

15. *Navicula didyma*, var. γ. To the four preceding forms I add one more, which I do not venture to erect into a new species. It has the form and size of a very frequent form of *N. didyma*, but with the entire or costate striæ of Nos. 11 and 12. This character would lead us to make it a *Pinnularia*, were it not that de Brébisson, and even Professor Smith himself, who gives it as a character of *Pinnularia*, have referred, in *N. pandura* and *N. nitida*, costate forms to the genus *Navicula*. At least I am so informed as to *N. nitida*, for I have not seen Smith's description of it, nor an authentic specimen named by him. De Brébisson's figure of *N. pandura* speaks for itself.

I have figured the costate form, which, for these reasons, I refer for the present to *N. didyma*, in fig. 15. No detailed description of it is necessary, and I need only say here, that I frequently meet with it in the Glenshira sand, along with the other forms of this group, which I have figured, and that, besides the two common forms of *N. didyma*, well figured by Smith, our depòsit contains one, if not two other varieties which have moniliform striæ, and which I refer also to *N. didyma*, a species which, like *N. elliptica*, Kütz. (*ovalis*, Sm.) and *N. elliptica*, Sm. (*Smithii*, Bréb.), appears to vary much both in outline and general aspect.

16. One of these is represented in fig. 16. It is frequent in the deposit. I call it *N. didyma*, δ.

It is evident that all these constricted forms belong to one group, but how they are to be classified it is not easy to say. The following questions naturally occur:—1. Do the costate forms constitute one or more species? 2. Are the moniliform types of this group to be referred to one or more species? 3. Is it possible that all these forms, whether moniliform or costate, belong to one and the same species? and if so, how is that species to be defined?

If we refer them all to one species, or even if the form, fig. 15, be referred to *N. didyma*, or figs. 11 and 12 to *Navicula*, what becomes of Professor Smith's definition of *Pinnularia*, and how is that genus to be distinguished from *Navicula?* I do not pretend here to answer these questions; but I may state, that the form fig. 15 has every appearance of being a variety of *N. didyma* (agreeing precisely, as it does, in form and size with the commonest small form of that species, which is very abundant in the deposit); and if that be so, then we have moniliform and costate striæ in the same species. I may add that I have made observations on *N. elliptica*, Kütz. (*N. ovalis*, Sm.), a common fresh-water form, which tend to show that it passes into *N. didyma*,

equally well known as a marine form.* And I have also observed, that *N. elliptica*, which varies remarkably in all obvious characters, sometimes acquires a nearly, if not a perfectly costate striation, though usually strongly moniliform. As I propose soon to lay these observations before the Society, I shall not here go farther into the subject.

17. *Navicula clavata*, n. sp. This very fine form, represented in fig. 17, has at first sight some resemblance to *N. Hennedii*; but on close inspection, it presents remarkable characters.

Form elliptic, broad, with broad rounded projecting masses at the apices, which are the extremities of the median line. Striation marginal, as in *N. Hennedii*, but the inner bounding line of the striated band, instead of being purely elliptic, as in that form, becomes towards the extremities, nearly straight, so as to form a kind of angle, giving to the included blank space between it and the median line, a very remarkable form. Median line complex. First there is in the middle, as in *N. Hennedii*, a narrow line proceeding from each end, and terminating on each side of the centre, and at a short distance from it, in long rounded expansions; the other extremities are also rounded, but larger. Between the two central knobs lies a rectangular white space, extending in its length at right angles to the median line, and rather narrow. It reaches beyond the general width of the middle part, that is, the striated portion now to be mentioned, expands at the middle. On each side of the proper median line is a transversely striated band, which, near the ends, touches the median line, but near the middle, recedes a little from it on both sides. The striated band expands into large round heads, projecting beyond the true elliptical outline of the valve, and it also expands a little in the middle. The white blank across the centre appears to have at each end a small striated patch placed transversely to it. The large swollen ends of the complex median line, not only project, forming short snouts, but stand out strongly from the surface of the valve. The striæ appear rather coarser than those of *N. Hennedii*, about 20 in ·001″, and are very distinctly moniliform. Length of the valve, 0·0034″.

I may here mention that Dr. Greville has found in the same Trinidad sand which I have alluded to elsewhere in this

* I observe that in Vol. II. of the Synopsis, Professor Smith gives, as *N. elliptica*, Kütz. var. β, the form which I found in Lochleven, and which resembles *N. didyma*. I admit that it seems to be a variety of *N. elliptica*, Kütz., but I cannot find any essential difference between it and certain forms of *N. dydyma*. Is it possible that *N. elliptica*, Kütz. may take the form of *N. dydyma* in sea water, and that some other local cause may have produced the same modification in the fresh water of Lochleven?

paper, and which has yielded so many fine new forms, a still larger and finer *Navicula*, to which he has paid me the compliment of attaching my name. In this form also, we find the projecting, rounded, club-like snouts to the valve, standing out from it in the same manner. It is quite distinct from the form here figured, although, no doubt, the two forms belong to the same group. I think I have seen, in the Glenshira Sand, indications of a tendency in the larger forms of *Navicula Smithii*, Bréb. (*elliptica*, Sm.), to pass into snouted varieties, with the snout rising in relief from the surface of the valve.

I have not met with *N. clavata*, except in this deposit. (273.)

18. *Pinnularia longa*, n. sp. This remarkable form, of which an average example is represented in fig. 18, is not rare in the deposit, but, on account of its slenderness, is seldom found entire.

Form rhombic, very long and narrow, with acute terminations. Costæ very conspicuous, distant, inclined or radiate, about 12 in 0·001″. Length from 0·004″ to 0·008″, but usually about 0·006″. The only known form to which it has any resemblance is *P. directa*, Sm. But in *P. directa*, the form is rather lanceolate than rhombic, while the striæ are much more numerous, and are also parallel, reaching the median line, which those of *P. longa*, in the middle, at least, do not reach. Moreover, *P. directa*, so far as I have seen, is a much smaller form. *P. longa* has another peculiarity, which is, that the median line, as seen in the figure, is generally twisted. The valve appears very thick. (274.)

19. *Pinnularia fortis*, n. sp. This is a very pretty little form, and frequent in the lighter densities of the deposit. It is well represented in fig. 19.

Form nearly rhombic, or rhombic lanceolate, rather short, apices somewhat obtuse. Length from 0·002″ to 0·0035. Costæ conspicuous, about 16 in ·001, and apparently projecting from the surface of the valve, for on the edge view they seem to stand out, and the valve has, in consequence, a very peculiar aspect. The valve is also very convex towards the extremities, but concave in the middle, which gives to the F. V. a constricted form. There is a blank space at the centre, round which the costæ radiate. There is something about the form very difficult to reproduce in a drawing. The costæ appear very distant, yet when counted, we find them much more numerous than we expected; and if we give in the figure the real number, the whole character of the form is lost. This character is well represented in the figure, but there are fewer costæ there than in the original. It is a very well-marked form. (275.)

20. *Pinnularia inflexa*, n. sp. This is a remarkably neat little form, well marked, and frequent in the lighter densities.

Form elliptic lanceolate, ends acute. Striation conspicuous. Costæ subdistant, highly radiate, leaving in the centre a rather large round blank space, about 26 in 0·001″. Near each apex is a strong black cross-bar across the valve, which I believe to be caused by a depression in the valve, and I have named it from this character. Length 0·0014″. It is very uniform in its characters, and is well represented in fig. 20. (276.)

21. *Pinnularia acutiuscula*, n. sp. This is another well-marked species, frequent in the finer densities. Form long, almost lanceolate, with the sides parallel in the middle, and slowly converging to the acute apices. See fig. 21. Length from 0·002″ to 0·0026″. Striæ distinct and conspicuous in the middle part, from being more widely separated. They are also radiate, but less strongly so than those of the two preceding forms. They are finer than in these forms, and are about 30 in ·001″. The only form to which this one has any resemblance is *P. acuta*, but its peculiar form and aspect are quite sufficient to distinguish it. Both forms occur here, and when seen together appear quite different. (277.)

22. *Pinnularia Ergadensis*, n. sp. I have given this name, from *Ergadia*, Argyll, to the species represented in fig. 22.

Form nearly linear, or linear elliptic, ends rounded, obtuse, almost truncate. Length from 0·002″ to 0·0045″, or more. Striation finer than in *P. fortis*, but conspicuous; costæ about 25 in 0·001″, sub-distant, not quite reaching the median line, somewhat inclined. It is frequent in the lighter densities, and has a perfectly distinct aspect, so that it cannot be confounded even with *P. fortis*, the form which it most resembles, but in which the character of the striation is totally different.

As yet, I have met with none of the species of *Pinnularia* here figured, except in the Glenshira sand. (278.)

23. *Stauroneis amphioxys*, n. sp. This curious form is not unfrequent in the lighter densities, and is well represented in fig. 23.

Form nearly rhombic, tending to lanceolate, with acute apices. Valve highly convex, so as very often to present the dark appearance of an air-bubble, and, even in the best position, showing the margin as a broad black line. Stauras broad, reaching the margin, very transparent, so as often to be seen with difficulty, if in the least out of focus. At other times it is black, from the general convexity. Striæ fine, very nearly parallel, transverse, nearly 60 in 0·001″, not conspicuous, often apparently irregular, from the convexity of the valve. (279.)

(*To be continued.*)

NOTES *on some* FRESH-WATER CONFERVOID ALGÆ, *new to* BRITAIN. By ARTHUR HENFREY, F.R.S., Professor of Botany, King's College, London. (Plate IV.)

(Read March 26, 1856.)

PANDORINA MORUM, *Ehr.*

Pandorina, Ehrenberg (*Char. emend*). Frond a microscopic, ellipsoidal, gelatinous mass, containing imbedded near the periphery, sixteen or more biciliated, permanently active gonidia, arranged in several circles perpendicular to the long axis of the frond. The gonidia, almost globose, with a short, beak-like process, a red spot, and a pair of cilia which project through the substance of the frond to form locomotive organs upon its surface. Reproduction—1, by the conversion of each gonidium into a new frond within the parent mass; and 2, by the conversion of the gonidia into encysted resting spores, which are set free, and (?) subsequently germinate to produce new fronds.

P. Morum, Ehr. (Pl. IV., figs. 1-25.) Fronds hyaline; from about 1-80″ downwards. Gonidia either sixteen, and then arranged in four circles of 4, or thirty-two, and then in five circles, three at the poles of 4, and the intermediate three of 8 gonidia, which in the perfect form stand near the periphery and wide apart. In the forms which produce the resting spores, the gonidia are crowded together in the centre. The gonidia are green, but the contents of the resting spores, after they have become encysted, are converted into oily and granular matter of a bright-red colour.

The description of *Pandorina* given by Ehrenberg, is so incorrect, that no one would be able to determine the organism by its aid; but the figures in the '*Infusionsthierchen*,' although rude, are sufficient for identification. *Pandorina Morum* has been observed by Focke* and Alex. Braun† in recent years, who pointed out the errors of Ehrenberg in stating that the gonidia had only one cilium and no eye-spot; but we do not anywhere find a clear and satisfactory account of this creature. It was with much satisfaction that we received early in February of this year (1856), from H. Pollock, Esq., a bottle containing a vast quantity of *Pandorina Morum*, which he had found colouring the water in a pool at Hatton, near Hounslow, Middlesex.

* 'Physiolog.' Heft., ii. 1854, Pl. IV.
† 'Verjungung,' Ray Society's Vol. for 1853, pp. 169, 209.

The forms presented by this organism are exceedingly varied, and nothing can be more beautiful than a number of them revolving slowly on their long axes in a drop of water, as seen under a power of about 100 diameters.* In the first place, the perfect form exhibits two patterns shown in figs. 1 and 3, and there are minute counterparts to these, remaining in that state, as in figs. 7 and 9; while in the water where the species is actively multiplying, all sizes between figs. 13 and 14, just emerged from the parent frond, and the full grown from figs. 1 and 3, &c., occur. The form with 32 gonidia results from the cell-division going on one stage further than in the form with 16; but this difference is fixed during the earliest stages of development, as the form with 16 (fig. 1) never changes into that with 32 (fig. 3), after it has become free from the parent. In the perfect forms the gonidia are arranged near the periphery of the frond in circles, like the equator and parallels of latitude on a globe, so that *Pandorina* resembles Cohn's *Stephanosphæra* † more closely than any of the other *Volvocineæ*, that having a single equatorial ring of gonidia in its globular frond. Among the forms with the isolated gonidia occur others almost equally numerous with the gonidia collected together into berry-like heaps (figs. 15-20); these are smaller than the others, but equally varied in dimensions; their gonidia resemble those of the other form; they appear destined to form the resting spores.

The gonidia are almost globular; they have no proper membrane, but consist of a gelatinous, granular substance which contains a thinner fluid in the centre, as it contracts strongly by exosmosis when strong saline solutions are applied. There is a large, nucleus-like body (the chlorophyll-vesicle of A. Braun) at the posterior end of the gonidium (fig. 5), and at the opposite side is a short beak-like process, with a colourless space behind it; the pair of cilia arise here, and a little to one side and below these is the reddish-brown granule called the 'eye-spot.' We have never been able to observe a pulsating vacuole, as described by Busk and Cohn in *Volvox* and *Gonium*.

The gelatinous frond appears to be perfectly homogenous, without any boundary membrane. Iodine and sulphuric acid do not colour it blue. It is tolerably resistent, and appears solid, as it does not give way or become indented by external pressure, as is the case with the hollow frond of *Volvox*.

The fronds are multiplied by the conversion of the gonidia

* A. Braun says they revolve constantly to the right; but they change the direction constantly.

† 'Annals Nat. Hist.,' 2nd Ser., x., p. 321, &c.

into new families. If they are viewed at night, many of the fronds may be found at rest at the bottom of the vessel (in the daytime they assemble at the side next the light), motionless, and with the gonidia rounded and deprived of their nucleus. By covering up the bottle from the light, the development of the new fronds, which naturally takes place very early in the morning, may be retarded so as to be followed during the morning until noon. Some of the fronds may be found with the gonidia converted into berry-like heaps (fig. 10), others with the gonidia already distinct (fig. 11), while many parent fronds present the young fronds more or less regularly arranged in the softened and expanded parent mass (fig. 12), which ultimately dissolves and sets them free (fig. 13, 14). They then increase in size in proportion to the favourable conditions in which they are placed. I have never seen anything like what are described by Cohn in *Stephanosphæra* as 'microgonidia.'*

When kept for some weeks, an increasing quantity of fronds became accumulated at the bottom of the water, and these chiefly of the character shown in fig. 17, but devoid of cilia; and while many of them decayed, in others the gonidia became encysted so as to form globular cellules. Left for a fortnight, the water was found without a trace of green colour, with merely a brownish sediment at the bottom, upon examining which, it was found to contain a large number of berry-like forms (fig. 17), with the gonidia not only encysted, but with their contents converted into a red, oily, granular substance (figs. 21-25), as in the resting-spores of many Confervoids. The gelatinous frond was here almost dissolved away, and a slight pressure was sufficient to detach and separate the cellules, which are doubtless resting-spores, and destined to become subsequently developed into new fronds. This remains to be decided.

The organism thus described is a well-marked and distinct species, very different from *Volvox* and *Gonium*, but approaching near to *Stephanosphæra.* The form which produces the resting-spores, after losing its cilia, is Kützing's *Botryocystis Morum,* I have met with a form like this not unfrequently, but never before with the perfect *Pandorina.* Mr. Pollock tells me that he has collected from the same pond for some years past, but never found *Pandorina* before, and yet it colours the water green this season. *Volvox* seems, in like manner, to come and go at intervals of years, its revivification from the resting-spores depending much on external conditions.

* 'Ann. Nat. Hist.,' l. c. In a letter received from Professor A. Braun since the above was written, he speaks of the forms with small gonidia (figs. 7—9) as the 'microgonidial' form. A. H., June, 1856.

APIOCYSTIS BRAUNIANA, Nägeli.

Apiocystis, Nägeli. Frond a microscopic, hyaline, gelatinous, sac-like body, attached by an attenuated base; containing numerous green globular gonidia, multiplying, during the growth of the frond, by quaternate division, and finally breaking out by a lateral orifice as active, two-ciliated zoospores, each of which becomes encysted and grows up into a new frond.

A. Brauniana, Näg. (Pl. IV., figs. 26 and 27.) Frond pyriform, 1-600″ to 1-25″ high, the cavity filled up by gelatinous matter, in which are embedded the gonidia, at first few, increasing in number with age as far as 1600, each about 1-2000″ in diameter. Nägeli, 'Einz. Algen,' p. 67, Pl. ii A; Kützing, 'Spec. Alg.,' p. 208. Fresh-water ditches, &c.

A few young specimens of this little plant were observed in January of this year (1856) in a jar of water containing aquatic plants, brought from Wimbledon Common six months previously. The whole collection was destroyed by frost soon after, so that the development was not followed. Nägeli (*l. c.*) gives the following account of it:—

"The young 'swarm-cells' (zoospores) attach themselves by their ciliated point (especially to *Cladophora fracta*), and become invested with a club-shaped enveloping membrane. The first division of the green body then takes place in the direction of the axis of the vesicular envelope, and is repeated, in *A. Brauniana*, alternately in each direction of space. During this the vesicle in which the cells (gonidia) lie, continually expands, and generally becomes very evidently pedunculated. Young vesicles contain a regular number of cells, namely, 2, 4, 8, 16, 32, &c.; but the number afterwards becomes indefinite; in largish vesicles, 1-50″ long and 1-120″ in diameter, I have counted about 300; in the largest, about 1-25″ long and 1-50″ thick, some 1600 cells.

"The cells (gonidia) are at first uniformly distributed over the whole cavity of the vesicle. Subsequently they generally become collected on the internal surface of the wall of the vesicle, where they lie in one or more strata. But the cell-division always takes place in all directions of space, the cells situated internally advancing outwards towards the periphery. In old vesicles the cells are sometimes arranged in rings of 8 upon the wall.

"When the family of cells is mature for 'swarming,' which may occur at very different sizes and with very different numbers of gonidia, the cells begin to move at first slowly from their places, and then gradually to circulate more rapidly in and out about each other. The vesicle bursts and the gonidia emerge by the orifice which is formed. Sometimes the swarming is preceded by the state in which the cells are arranged in parietal rings.

"The cells secrete an abundant gelatinous coating, which becomes softened within the vesicle, and confluent into a structureless jelly. The vesicle sometimes appears merely as the boundary line of the jelly; in general, however, it may be distinguished as a distinct wall composed of denser gelatinous substance (Pl. IV., fig. 25), the internal outline of which is always distinct and sharp, while the outer is frequently indistinct and partly dissolved."

The vesicle sometimes presents delicate ciliary processes on the outside. The zoospores have two cilia, according to Al. Braun.* They have no 'eye-spot.'

CLATHROCYSTIS ÆRUGINOSA.

Clathrocystis, Nov. Gen. Frond a microscopic gelatinous body, at first solid, then saccate, ultimately clathrate, (fragments of the broken fronds occurring in irregularly-lobed forms,) composed of a colourless matrix, in which are imbedded innumerable minute gonidia, which multiply by division within the frond as it increases in size. (No zoospores or resting-spores observed.)

C. æruginosa. (Pl. IV., figs. 28—36.) Fronds floating in vast strata upon fresh-water pools, forming a bright green scum, presenting to the naked eye a finely granular appearance; when dried appearing like a crust of verdigris. Gonidia or green cells, with a distinct membrane, about 1-8000″ in diameter, leaving a hyaline border at the surface of the fronds; full-grown fronds, 1-50″ to 15″ in diameter. *Microhaloa æruginosa*, Kützing. ('Linnæa,' viii, p. 371, Pl. 8, fig. 23.) *Microcystis icthyoblabe*, Kütz., 'Phyc. Gen.' *ex parte*. *Meneghini*, 'Monogr. Nostoch.' p. 104. *Microcystis æruginosa*, 'Tab. Phyc.' i., Tab. 8. *Polycystis æruginosa*, Kütz., 'Sp. Alg.,' p. 210. "*Flos Aquæ*," 'Treviranus,' Linnæa, xvii., p. 51, Pl. 3. On fresh-water lakes.

This remarkable form does not appear to have been observed hitherto in Britain. We found it in the autumn of 1855, forming a scum extending over a large portion of the surface of the lake in the Royal Botanic Gardens at Kew. A portion of it, brought home and preserved in a room in a bottle of water, continued to grow healthily until the middle of winter.

It is very well described in the paper of Treviranus above referred to; but none of Kützing's descriptions mention its remarkable mode of growth or its peculiar form when perfect. Apparently that author has only seen it in a dry state; it does not agree with the definitions of the genera *Microcystis* or *Microhaloa;* and as the name *Polycystis* has been occupied in the Fungi, we have ventured to add to the already confusing synonymy, by giving it a distinctive and characteristic name.

The smallest fronds met with are usually roundish or ellipsoidal, of the character shown in Pl. IV., figs. 28 and 34. When quite young they appear to be solid, but as they grow by the multiplication of the internal gonidia, and the secretion of gelatinous matter, the expansion takes place chiefly near the

* 'Verjungung,' &c., Ray Soc. Vol. 1853, p. 209.

periphery, so that the frond becomes a hollow body (just as the stems of Grasses or *Umbelliferæ* become fistular). The walls of the sac then give way, (figs. 29 and 30,) and as the expansion proceeds, orifices are formed in different parts, until the whole becomes a coarsely-latticed sac or clumsy net, of irregularly-lobed form (fig. 31). Then this becomes broken up into irregular fragments (figs. 32—34) of all shapes and sizes, (giving the stratum a granular appearance to the naked eye,) each of which recommences the expanding growth, and becomes a latticed frond. The internal cells are very minute, but have a distinct margin with internal granules (figs. 35 and 36). They multiply by dividing into two or four. The gelatinous frond always presents a transparent border or peripheral stratum, destitute of green cells; but no boundary membrane exists, the surface exhibiting a softened or half-dissolved aspect. On the approach of winter the fronds ceased to increase, and by degrees most of the gelatinous masses faded to a light brownish tint, swelled up and settled to the bottom of the water in light flocculent clouds. They appear to become half dissolved, and to allow the green cells to become free, as many of the latter were found free, adhering to the sides of the vessel; perhaps these reproduce the fronds in the next season. No zoospores were ever detected.

The verdigris-like appearance of this *Alga* when dead is most remarkable and characteristic. While growing, in its wet state, it is rather of a yellowish opaque green colour.

As to the systematic position of the above species, *Pandorina* belongs, of course, to the *Volvocineæ; Clathrocystis* is doubtless referable to the same group as *Palmella cruenta*, and therefore to the family of true *Palmellaceæ*, which will require to be kept apart from *Protococcus*, and similar forms, on account of the absence of zoospores. *Apiocystis* must remain for the present in the heterogeneous assemblage which includes *Protococcus*, *Glœocapsa*, &c., which require much more study before they can be satisfactorily classified.

On a METHOD *of* ILLUMINATING OPAQUE OBJECTS *under the Highest Powers of the* MICROSCOPE. By F. H. WENHAM.

(Read March 26th, 1856.)

REPEATED experiments have shown, that it is a matter of extreme practical difficulty to contrive any method of condensing light directly down upon an object, when viewed under an eighth or twelfth object-glass of large aperture. In the first place, the close proximity of the front lens and its setting, will only allow a thin conical disc of light, to find a passage towards the object, at an angle of seldom less than 100°, or at an obliquity far too great to be practically useful; and secondly, when the object is covered with thin glass, considerably more than half the light will be lost by the reflection from the surfaces, the rays from which enter the microscope, and occasion an amount of glare and fog sufficient to obscure the object; for these reasons I think that there is but little chance of obtaining any useful result in this direction.*

The methods that I now bring before the Society are based upon an entirely different principle, which is not applicable to *dry* objects, but only to those mounted either in Canada balsam, fluid, or any other refractive medium. An experience of nine months warrants me in the assurance of its complete success, as a means of investigation—objects being brilliantly illuminated in a jet-black field, with an objective of 170° of aperture or more.

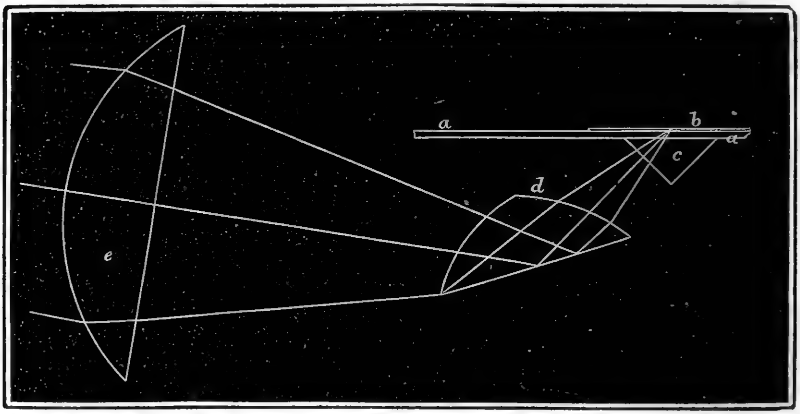
The principle of operation consists, in causing rays of light to pass through the under side of the glass slip upon which the object is mounted, at the proper angle for causing *total internal reflection from the upper surface of the thin cover*, which is thus made to act the part of a speculum, for throwing the light down upon the under-lying objects, immersed in the balsam or fluid.

As there will be no total reflection from the planes of a parallel plate of a refractive material, it is necessary to adopt some method for allowing the rays to enter the medium at such an angle as to cause total reflection from the upper surface. There are many methods of effecting this; those which I now describe I have found to be the most practicable and useful: *a*, *a*, fig. 1, is a glass slide containing objects mounted in balsam; *b*, thin glass cover; *c*, is a right-angled prism

* Since the above, Mr. Ross has shown me his ingeniously-contrived Leiberkuhn, applied to the highest powers for illuminating *uncovered* opaque objects, and which performs most admirably; to my mind undoubtedly proving the fact, that the minute scales from the wings of butterflies, &c., are perfect *cellular* structures.

cemented on to the under surface of the slide with Canada balsam; *d*, is an Amici prism for condensing and directing the rays into the prism *c*; *e*, is a large bull's-eye condenser placed with its convex side towards the lamp.

Fig. 1.

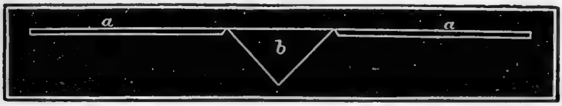


Making ample allowance for all possible differences of refraction in the slide, balsam, and cover, the angle of total reflection for the mean refrangible ray, will vary from 40° to 45° from the perpendicular—at any rate it will never exceed the latter degree; consequently for this reason I consider the right-angle prism the most convenient for most purposes, as the rays may be passed perpendicularly through its surfaces without any trouble arising from refraction.

The mode of action illustrated by the diagram is simply as follows: the rays from the luminous source are first collected and converged by the large bull's-eye lens *e*, and then further condensed and directed upwards by the Amici prism *d*; they next enter the surface of the right angle prism *c*, and pass directly onwards till they reach the upper side of the thin cover, from whence they are totally reflected down again, forming a brilliant surface of light, which will of course illuminate any small bodies immersed in the balsam just below. If the cover is clean and free from scratches, not the smallest portion of light from the luminous source will find its way through. The view of the objective will be unimpeded, and the field perfectly black. Another way of causing the light to enter the prism, is by means of a parabolic condenser, adjusted as under ordinary circumstances; the light will in this case enter the two faces of the prism at the same time, which is some advantage; it must be sufficiently small to have some

play in the cavity at the apex of the paraboloid; if the right-angled faces are one quarter of an inch square, it will perform very well. The objection to the plan just described is the necessity of having a separate prism for every object, which, though of advantage in some remarkable and peculiar cases, is not necessary for all. Fig. 2 is more universal in its applications; *a a* is a thin plate of brass, *b*, a right angle prism let in exactly flush with the upper surface; any small objects

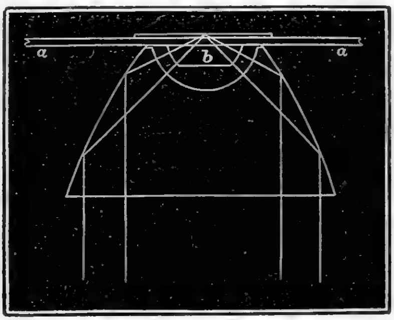
Fig. 2.



such as animalcules, *Diatomaceæ*, pollen, &c., must be laid upon the prism with water, and covered with thin glass; total reflection will then occur from the uppermost surface, in the same way as in fig. 1, and illuminate the objects in the fluid. Any ordinary plane slide containing objects mounted in balsam may be placed upon the plate and prism, first interposing a drop of water. It is almost unnecessary to remark that if this, or some other fluid is not interposed, the rays will all be reflected from the back of the prism itself, instead of passing onwards into the slide.

Fig. 3 is another method; *a a* is a glass slide—under this is cemented with Canada balsam a lens, *b*, nearly hemispherical, with a segment removed so as to leave the thickness equal to about one-third the diameter of the sphere. The flat facet of the lens is blackened. The radius of curvature should be about two-tenths of an inch: the use of the blackened facet is to exclude all rays below the incident angle of total reflection. This lens is intended to be used in conjunction with the parabolic condenser, in the manner represented by the figure. The rays from the parabola pass through the surface of the lens in a radial direction without refraction, and proceed till they reach the upper surface of the thin glass cover, where they are totally reflected and converge upon the object; the

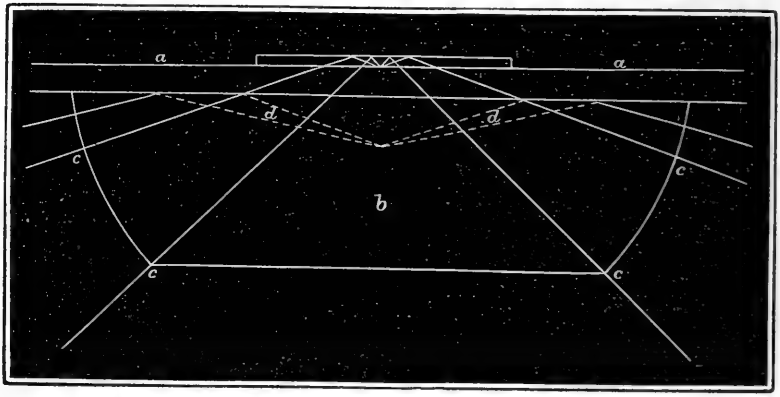
Fig. 3.



cover in this instance acts precisely the part of a Leiberkuhn, with the advantage of more perfect reflection.

A lens of this description may be let into a thin plate of brass as in fig. 2, and used in the same way as an aquatic holder, the parabolic condenser always being used for concentrating the light. When a slide containing balsam-mounted objects is placed above the lens, instead of using water, it is preferable to employ turpentine, or oil of cloves; the refractive index of the latter being nearly the same as crown glass. The reason for introducing this agent is because light impinging upon the polished plane between a greater and a less refractive medium, will always suffer total reflection at the surface of the former, at a given angle dependent upon the relative refrangibilities. If water is used, the angle of the illuminating pencil will be limited to about 160°; above this, all rays will be reflected down again by the flat surface of the lens, and lost, as shown by fig. 4; *a a* represents the glass slide, with

Fig. 4.

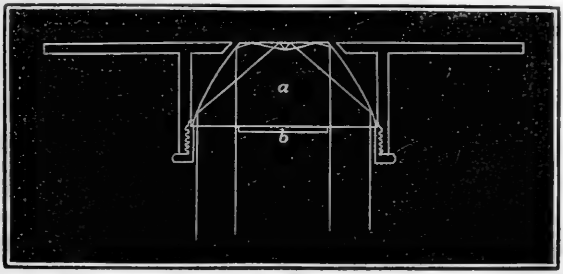


objects in balsam; *b* is a hemispherical lens placed underneath the slide, with water interposed; *c c*, rays which pass onwards to the top plane of the thin glass cover, to be reflected down again upon the object: the dotted lines, *d d*, are the portions of the illuminating pencil, that will be lost by being reflected from the flat surface of the *lens*—of course if a medium of nearly the same refractive power as the glass is used, such as oil of cloves, all this light will be transmitted and rendered available.

Another variation in this principle of illuminating opaque objects, is that illustrated by fig. 5: *a* is a small paraboloid of solid glass with a flat top. A black stop, *b*, of the same diameter as the apex, is fixed at the base of the parabola, for

the purpose of stopping out direct rays. This paraboloid is set in a ring, which is screwed underneath a flat brass plate,

Fig. 5.



so as to bring the upper plane surface of the glass exactly level with that of the plate in the manner shown by the figure. The parabola must be sufficiently short to prevent any rays from passing *within* the angle of total reflection relative to the flat top—or the paraboloid may be cut off at the point in the curve intersected by an angle of 45° drawn from the focus.

If a powerful series of parallel rays be sent into the base of this paraboloid, not any of the light will find its way through the upper flat surface. The whole will be reflected down again into the body of the glass. If now a piece of thin glass is placed on the top, with a drop of water, the greater portion of the illuminating pencil will be transmitted to the upper surface of the cover, and from thence totally reflected, illuminating any small objects contained in the fluid. Glass slides containing balsam objects may be placed on the apex of the paraboloid, using an intermedium of turpentine, camphine, or oil of cloves, in preference to water. This same reasoning also applies when small objects are viewed directly in fluid, by being laid on the flat top of the paraboloid, and covered with thin glass. When the nature of the substances will admit of it, for the purpose of obtaining greater intensity of illumination, they should be placed in turpentine or oil of cloves; in this case the whole of the light will be reflected from the top surface of the cover—no separate reflection taking place from the upper plane of the paraboloid, as with water. In using this instrument, all that is required is to throw direct light into the parabola, by means of the concave mirror.

Having now described some modifications of this principle of illuminating opaque objects, as most especially adapted for the highest powers, numerous experiments will justify me in saying a few words as to the effect. The light may be obtained of any required degree of intensity, and the field per-

fectly black, with objectives of the most extreme aperture; some *Diatomaceæ* mounted in balsam, are shown with a degree of beauty and delicacy, that I have never seen equalled, and from the lights brilliantly illuminating the prominences on the surface, many of them wear an entirely different appearance to the same objects seen as transparencies, and from the absence of all irregular refraction and colour, and the purity of the vision, the mind is impressed with the fact, that we are viewing them under their true features, as cellular structures, and in some instances displaying such a singular arrangement and configuration of markings, in cases where I had not even suspected them to exist, that I shall on a future occasion give some illustrations of them. It must not, however, be expected that all the *Diatomaceæ* can be seen by these methods, for some of them, when mounted in balsam, are so exceedingly translucent, that they will not hold a sufficient quantity of light, to be viewed as strictly *opaque* objects.

For this method of illumination, the greatest nicety is required in the adjustment of the object-glass, the slightest defect in this causing milkiness and indistinctness of vision—indeed so particular is the care required in this respect, that a different adjustment is sometimes necessary for various parts of the same object, in a case where it lies in an inclined position in the balsam.

With regard to the relative merits of the three methods that I have mentioned; for those who are already possessed of a parabolic condenser, the preference is most decidedly to be given to the hemispherical lens, fig. 4, set in a very thin plate of brass, but the truncated paraboloid, fig. 5, is by itself a most convenient piece of apparatus, readily applied and easily managed, forming a most useful adjunct to the other.

On the VEGETABLE CELL. By F. H. WENHAM.

(Read May 28th, 1856.)

IN the 'Annals of Natural History' for May, 1856, there is a notice, by Professor Henfrey, relating to my paper on 'Cell Development,' published in the 'Quarterly Journal of Microscopical Science' for Jan. 1856. I prefer making my reply through the medium of the same Journal, which is accessible to all whom the subject may concern.

The notice commences by saying:—"The essay contains internal evidence of the author's want of familiarity with the subject treated." It does, in all probability, contain irregularities and omissions which may possibly be excused in an inexperienced writer on these particular subjects. I pretend

to be nothing more than a sincere searcher after the truth, uninfluenced by motives of ambition or notoriety; and it is not fair that I should be criticised according to the same rigid rules which would be applicable to an established professor. As regards "want of familiarity with the subject," I can only say, that for years past I have examined the development of the vegetable cell, and have been trying, without success, to reconcile the facts that I have observed with the written statements of Mr. Henfrey; for it is to these, or such as have appeared under his sanction, that I have made the most particular reference. This is my excuse for not viewing these things through the medium of Mr. Henfrey's eyesight, and for falling back upon my own judgment; and I trust that I may be pardoned for so doing. Even to this hour the cell theory is by no means a settled question, and I would advise those engaged in this study to form their ideas less upon a groundwork of contending theories, and apply more diligently and directly to the book of nature for information.

It is to be regretted that any remarks should give rise to this form of reply, so directly out of the course of correct scientific discussion. I will now proceed to notice Mr. Henfrey's objections, which are scanty enough. He first says, in reference to me:—"The objects selected were *unfavourable*, and not favourable as he imagined; for young leaves of most flowering plants, in the stages figured by him, are not flat plates, but cones, or at all events solids having more than one thickness of cells in all three dimensions; therefore the view is confused by one layer lying behind another." In reply to this I may say, that if Mr. Henfrey had condescended to read my paper before thus perverting my meaning, he would find these subjects described as "cellular-cones," or "nodules of protoplasm filled with cell-cavities;" so that this objection must at once fall to the ground: and to avoid the delineation of that confusion he mentions, I had drawn directly with the camera lucida *the top layer of cells only*, and any error in form and position is a trifling one, occasioned by the object being slightly flattened in the compressor.

Mr. Henfrey further remarks:—"But even in the leaves of *Anacharis* the application of dilute sulphuric acid and solution of iodine suffices to render the structures clearly distinguishable, as quite different from what is represented in Mr. Wenham's drawings." No doubt of it! I believe that there are but few recent vegetable structures that would submit to such treatment unchanged. I have tried numerous experiments with these and other re-agents, but ceased to place much confidence in them for the investigation of very young

cells; for, though they are most useful for testing the transition stages between protoplasm, starch, and cellulose-layers, &c., they are extremely prone to develop an appearance of membranes and organisms that do not really exist. I much prefer, when the case will admit of it, to view the structure and note the successive stages of development under natural conditions. I am, however, far from wishing to disparage the valuable test referred to. The effect of sulphuric acid and solution of iodine, in the young cells in the cases in question, is to cause the cavities in the formative plasma to become more distinctly apparent, *as perfectly clear spaces*, containing nothing else but a watery fluid. The objection that I have sometimes found in using it is, that in the boundary of a consolidated plasma, known to be homogeneous, it is apt to develop the appearance of layers, or zones, not arising from cellulose deposits, but caused by the grades of chemical action of the test. When young cells contain but a small quantity of contents, another fallacy may arise, from the application, for they become drawn together in the centre of the cavity, appearing as a ball of nucleus.

As a further explanation, which must be considered supplementary to my former paper, I have now some additional remarks to make on vegetable cell development.

The basis of a cellular structure in its first stage,—consisting of a membranous sac filled with an uniform plasma, or mass of formative material,—may be termed by some, "the primordial cell;" but in my view improperly, for the external membrane is merely protective, it exerts no active influence upon, and is unconnected with the subdivision, or cellulation of the contents, and, taken as a whole, has none of the functions of an individual cell.*

Now we have here a vesicle filled with formative material, ready to break up into a group of cells. Those who have examined for themselves with the requisite degree of care must recognize a *simultaneous development*,† numerous rudi-

* When the cuticular envelope, containing the uniform plasma, is ruptured under water, the protoplasm sometimes escapes as a globule, which speedily becomes filled with vacuoles. These rapidly enlarge and increase in number, till the whole becomes spread out and diffused in the fluid. The tunic, or envelope of young cells, does not at first, in all cases, possess an uniformity of surface; for, in many plants it is spinous, or covered with tubercules, at its earliest stage; these are the rudiments of hairs. It is remarkable at what an early period they are perfectly developed, even before a definite or complete cellulation of the plasma, that they have sprung from, has taken place; some of the hairs being already jointed, and showing sap-currents in their cells.

† When the bark is stripped from the growing branches of exogenous plants, early in the spring, the surface of the wood is covered with a slimy

mentary cell-cavities appearing spontaneously throughout the mass at the same time, and increasing independently of each other; in every one the inner lining of each space in the formative protoplasm becoming hardened into a membranous layer, which may be readily proved, as the unconnected cell-sacs can be washed out of the containing plasma and isolated. The "vacuoles" are rather apt to take their rise from the larger particles contained in the plasma, but I believe that this is only a mechanical and not a vital condition, for it is equally certain that a large number of them form themselves apparently without any starting point whatever. In *Anacharis*, and many other plants, these cells, in the first stage of their existence, are simple membranous sacs, containing nothing else but a limpid, watery fluid, and a few very minute granular bodies adhering to the cell-wall—and here is a point at issue. It is maintained that cells, even in their very earliest stage, contain an active nitrogenous layer lining the interior of their cavities—the so-termed "primordial utricle." My own observations cannot confirm this; and, indeed, reasoning independently of the evidence of eye-sight, it seems an anomaly to expect a detached portion of a material to be enveloped in a cavity *of its own substance*, before any limitary membrane is completely formed to prevent their coalescence. Neither can it be set down as a general rule, that new cells are commenced singly around a collection of solid contents, for "vacuoles" are to be seen of the minutest size, which are afterwards expanded, so as to become perfect cells in all respects; unless in this case it is assumed that the formation takes place around invisible contents.

As I have before stated, it is not until the membrane of the sac is completely formed, that protoplasm is found *within* the cell; this is rapidly followed by the deposit of internal

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film of protoplasm, in a free state; if this is scraped off it will be found to contain transitional cambium cells, dotted ducts, &c., in all stages of development. The formative plasma is mostly deposited in the form of strips, in the grooved surfaces of the bark and wood, and there rapidly resolves itself into a row of cells, or hardens into a fibre, according to the influences of local conditions, or the size of the matrix. These cells are not formed by the division of older ones, but arise directly from the *simultaneous cellulation* of the formative plasma, in the manner that I have explained in other instances.

From the light colour of the substance it is a difficult matter to investigate the young cellular deposit, as an opaque object; but after the surface has dried, an impression may be taken with black sealing-wax, which will also sometimes bring away some of the young cells in course of formation, and afford a more satisfactory view of the cell stages and arrangement, using a Leiberkuhn for illumination.

secondary layers, and the appearance of other constituents, as starch, chlorophyll, &c.

The sooner the term "primordial utricle," as applied to the active nitrogenous *fluid*, or protoplasm, flowing round the interior ofthe cell-cavities, is discarded the better, for a clear understanding of its all-important properties as the formative principle. If even a viscid fluid can be endowed with the properties of a membrane, it is not at all times so in this case, as it frequently collects in the form of clots, or nuclei (as some might term them); thus changing its name and appearance perhaps several times during the course of a day.

The specimens drawn for illustrating my last paper originated in a plasma so homogeneous and free from all extraneous matters, that the cell-cavities were clear from *first* contents; in fact, this is mostly the case with *Anacharis* and some other aquatic plants; the cellulation occurring in a mass of protoplasm nearly pure; but this is not so in other instances.

What I have already said of cellular formation might serve as a guide to the principle to which my investigations have led me, but it may now be proper to notice some frequent variations, which at first sight might not appear reconcilable to my views: I refer to tissues originating in a mass of cells, *not hollow* at their commencement, but with their cavities completely filled with contents (and hence I have always hesitated in making use of the general term "vacuoles"). This condition is easily observable in some leaves and germinating seeds, where the formative substance contains a larger quantity of extraneous matter; under such circumstances the process of cellulation is in no way different, for relieving the mind from the task of attempting to reconcile the theory of the subdivision of an unity (and the relationship of "*mother and daughter cells*"), and admitting the principle of a *simultaneous development of cells*, the denser granulated material of the original plasma, in its first stage of cellulation, is shown to arrange itself in the form of irregular squares, trapeziums, or oblong figures, partitioned off by thick divisions of more transparency and consistency. This is the true protoplasm, which has separated from its solid admixtures, or expanded from centres, as it were, to form the cell walls, a process to which Dr. Carpenter has so appropriately applied the term "differentiation;" * but it must not be supposed that these

* This term is also explanatory of the formation of the simplest types of shell, which have arisen from a plasma containing calcareous matter. The "sarcode" (analogous in vital properties to vegetable protoplasm) having separated into somewhat irregular divisions, and formed a membrane between the nucleated and consolidated calcareous matter, producing a rude cellular structure. In some more perfect developments of shell

rudimentary walls, or rather septa, become one uniform and continuous solid—the *true* cell wall is still formed in the interior of each cavity, with the appearance of being moulded upon the mass of contents, and when the membrane has acquired consistency, the proper cell constituents arise within, from external absorption as in former instances. The cells may now be washed out from the intervening plasma in which they are imbedded, as separate sacs just in the same way as I have described before.

The expanding action of the living protoplasm, may be seen in actual operation during the conjugation of the *Desmidieæ*—a process that I have always watched, with never-failing interest. When the two masses of endochrome are ejected, they are not bounded by any limitary membrane as some seem to suppose, but unite at first oftentimes in the form of a rugged mass. All the intervening protoplasm now separates from the general mixture, and forms an external sheath, which hardens into a membrane—the cell wall of the unicellular sporangium.* I bring this forward again, because the expansive effect of the protoplasm, as seen to take place here, will illustrate the action in the associated cells in question, when filled with contents, by considering each cell in the formative plasma for the time being, as a separate and independent organ.

If now one system of cells are first formed with empty cavities, and another with more or less of *primary* contents, the question arises, what ought to be the physiological difference in favour of the subsequent vital welfare and development of the latter? As far as my investigations have gone I cannot say that the full cells appear to differ much in growth, or derive after benefit from the circumstance of their first replete condition, the well-doing of the cell still depending upon *external* conditions; but without going so far as to state

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structure, there seems to be a beautiful combination of this vital action, in conjunction with *definite chemical arrangement*, or a crystallization of the calcareous deposit, giving rise to very regular and perfect cellular forms, and prismatic structures. It would be a very interesting inquiry to ascertain how far these two forces act together in harmony, in forming regular cell arrangements in other departments of the animal and vegetable kingdom. This would be an investigation in which the polariscope would be extremely serviceable.

* In some of the *Desmidieæ* and *Algæ*, when the endochrome or contents of one cell are forced out, by the application of gentle pressure, into the water, the first action is somewhat similar to that which takes place during conjugation. The protoplasm separates from the other constituents, and is determined outwards as a complete envelope, the mass acquires a spherical shape, and remains so for many hours, but no consistent exterior membrane is ultimately formed; all vital action ceasing at this point, the mass always proving barren.

that the primary contents are useless for the purposes of nutrition, I will merely mention that some recent and most valuable practical researches, made by an independent observer (and which I trust he will shortly bring before the public), have proved that extraneous matters may be conveyed into the mass of the formative plasma, and substituted for the contents of the primary cells, without interfering with the growth, and of such a nature as to afford *no* nutriment to their tissues.

In conclusion I beg to inform the Society, that though the microscope has led me to take up particular views of cell development, I do not profess to write a complete essay on the subject. I will, however, remark, that it is still quite a new field for investigation, for all the controversies and contending theories that for years past have appeared on this theme have done but little towards the enunciation of a simple system of laws. As cell formation undoubtedly takes place, in various grades of complexity, the lowest and highest being widely different in their mode of production, in order to simplify this most important branch of science, I would venture to suggest, with all due deference, the possibility of classifying the subject, by arranging it in heads or departments, or to make myself understood, say as follows:—

1. Spontaneous appearance of membranous cavities in a primitive plasma, or simple *differentiation.*
2. Cell formation by self-division, or the conjunction of definite membranes or utricles.
3. Cells requiring special organs for their production.
4. Allied phenomena, &c.

If this were accomplished it would save some amount of confusion; much of what is already known might be arranged under such heads as these. In the most highly organised plants, it is probable, that all these modes of cell formation separately exist, in various organisms.

It is to after influences, or vascular bundles arising from the parent stem, that the proportions of symmetry and form are conveyed to the embryo cellular mass, dividing, distributing, or increasing it according to its destined condition. At the time that these vessels and ducts begin to force their way through the young assemblage of cells, these differ so much in both individual form and arrangement, as to be typical in nearly all cases of the most excessive irregularity (the embryo leaves of the vine may be taken as an average example), and is utterly irreconcilable with the idea that the cavities or cells *originate* from the regular division and subdivision of primordial cells.